New Scientist

WEEKLY 1 July 2023

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Groundbreaking treatments save lives before birth

DARK MATTER HUNTER
Euclid space telescope will find what's missing in the cosmos

POWERING UP
Inside the factory making the world's greenest batteries

SPECIAL ISSUE

CIVILISATION

The new evidence rewriting the origin story of our modern world

THE EASY WAY TO GET FIT
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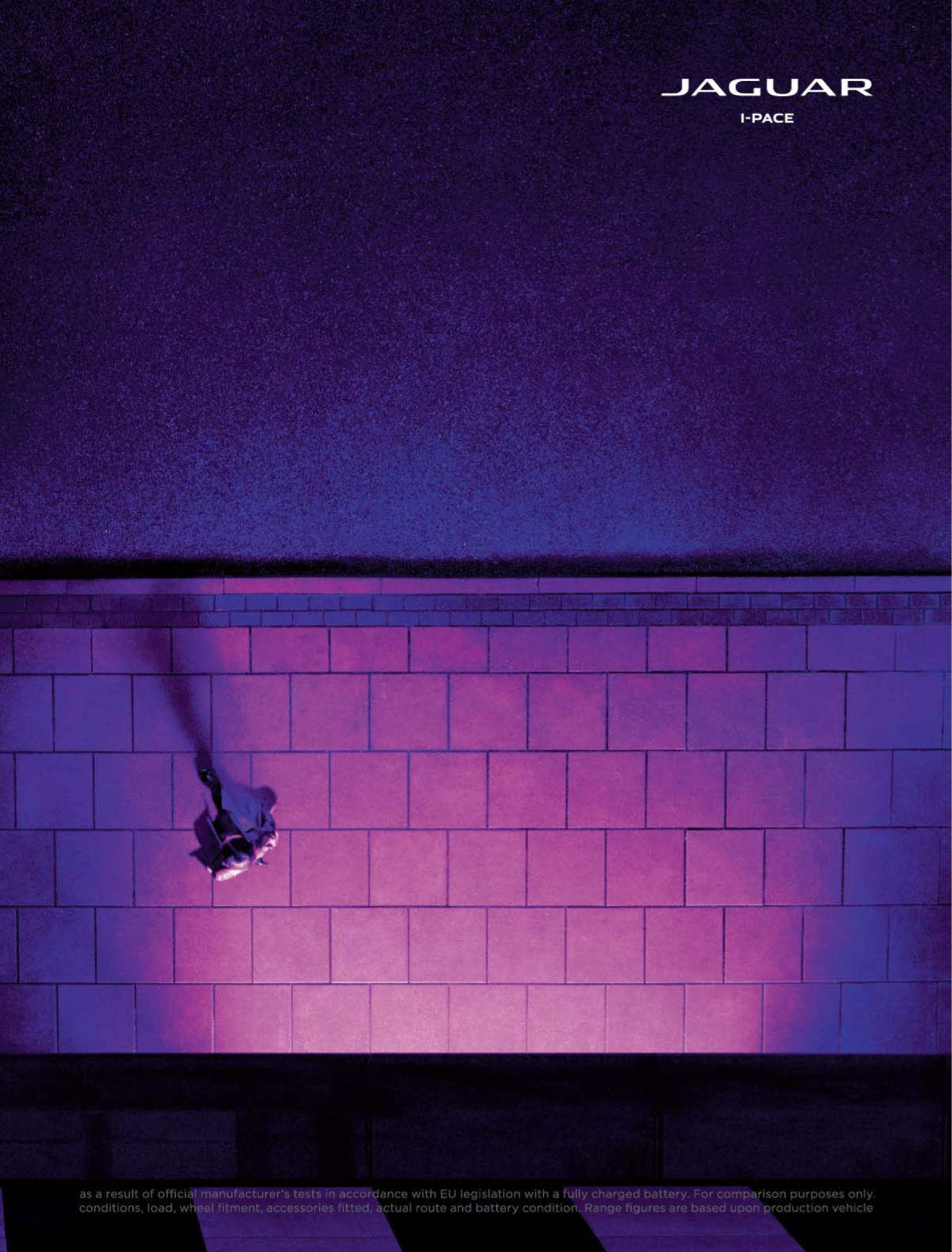

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Tour

Science of the Arctic Expedition Cruise: Svalbard, Norway

Explore the northernmost region of Earth with *New Scientist*'s Rowan Hooper. Aboard a state-of-the-art expedition vessel, you will gain extensive knowledge of marine and polar nature while exploring this rugged archipelago. Witness polar bears on ice flows and beluga whales, before exploring the Arctic town of Longyearbyen. The 13-day tour begins on 18 June 2024 and tickets cost £9995.

newscientist.com/tours

NS Live

Ancestors: A history of Britain through burials

What can a grave tell us about a person and past cultures? At New Scientist Live on 9 October, Alice Roberts explores how burial archaeology sheds light on ancient societies, and looks at how genetics is completely revolutionising what we know about the past.

newscientist.com/nsl

Podcast

Weekly

The team discuss a new therapy being used to treat a rare genetic condition in babies while they are still a fetus in the uterus. They also have a glimmer of good news about extreme heatwaves and climate change. Plus, the orcas are revolting! Find out the truth behind the killer whales being filmed attacking sailboats off the coasts of Portugal and Spain.

newscientist.com/nspod

STEPHEN HYDE/ALAMY

Secret lives What can a grave tell us about ancient societies?

SHOTSHOP GMBH/ALAMY

Psychedelic awakening New insight into LSD's action on the brain

Video

The maverick of medicine

In this video, *New Scientist* talks to actor Mark Rylance, writer Stephen Brown and director Tom Morris about their new play *Dr Semmelweis*, which spotlights the work of this rebellious 19th-century obstetrician. The play is on at the Harold Pinter Theatre in London, UK, from 29 June.

youtube.com/newscientist

Newsletter

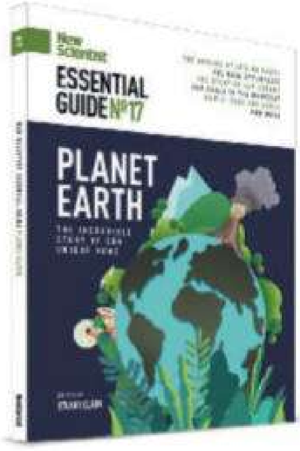
Health Check

Reporter Grace Wade has been in Denver, Colorado, attending the largest ever psychedelic drug conference. She discusses the spiritual experiences religious leaders have had when taking psilocybin, how these drugs may help people with eating disorders and the controversies over their use.

newscientist.com/health-check

Podcast

> **"The fetus gulps down the treatment in the womb... and it works"**



Essential guide

Our planet still holds many secrets. How did Earth form? How is it changing with global warming? And are there other Earth-like worlds out there? This *New Scientist Essential Guide* offers answers. Available to download in the *New Scientist* app or to purchase in print from our shop.

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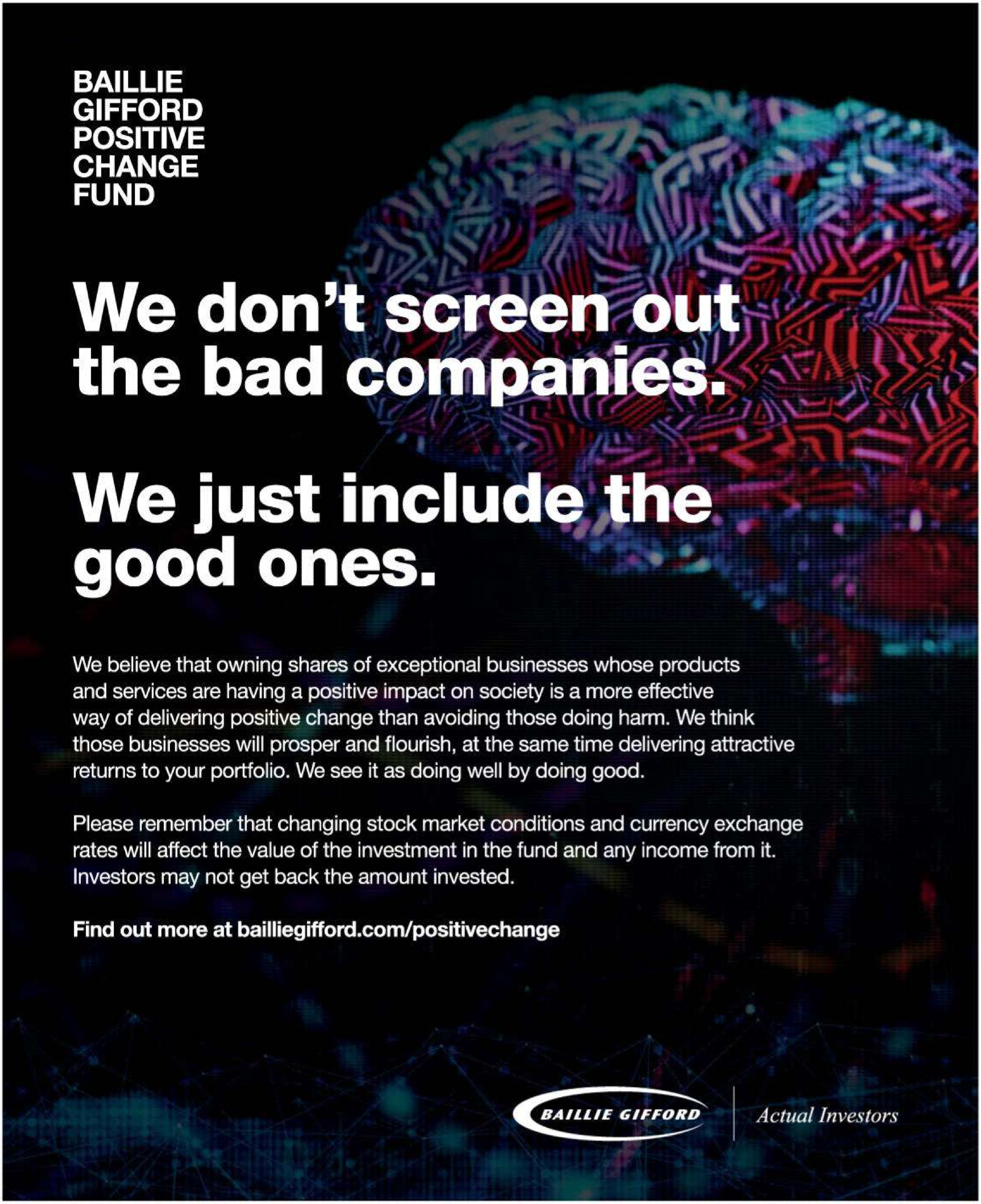

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Change is possible

The nature of civilisation is far more malleable than we thought

WHY is society the way it is? We thought we knew. Now, it appears, we have been thinking about it all wrong.

In our special issue on civilisation (see page 32), we explore what has happened to human societies over the past 10,000 years and what came before. It details new evidence on why many of us abandoned hunting and gathering for a life of farming, urbanism and paperwork, and explores why societies became more unequal and hierarchical, including the role war and religion played in such transformations.

The answers are nuanced, but the most powerful idea that comes out of the latest interpretations of our history is that we have a lot more control over social change than we thought. Many interpretations of the switch to modern society have portrayed it as inevitable: a process that is inexorable once started. The transition to farming, for instance, is often portrayed as a trap. Once people started farming, it became impossible to stop because the population swelled, the need for a stable food supply only grew and elites emerged to dominate everyone else.

> "The past tells us that we have the power to influence how societies live, work, fail and prosper"

In reality, human history was a lot more varied than this. Over and over, we see people trying new kinds of society, only to reject them and attempt something else. Hierarchies and elites have been toppled by popular uprisings. Societies have taken a kaleidoscopic range of forms rather than being limited to crude binary choices like capitalism versus communism.

When seen in this light, the shaping of human society is a far more creative exercise than we think. This new view of history is also inspiring and uplifting: if we don't like aspects of our current society, we can change them.

That lesson is particularly relevant now. We are living through a critical moment in history; a crisis when powerful forces like climate change, AI and populist authoritarianism are reshaping our world in unpredictable ways. It is easy to feel helpless. But we aren't. The past tells us that we have the power to influence how our societies live, work, fail and prosper. Big change can happen. History proves it. ▮

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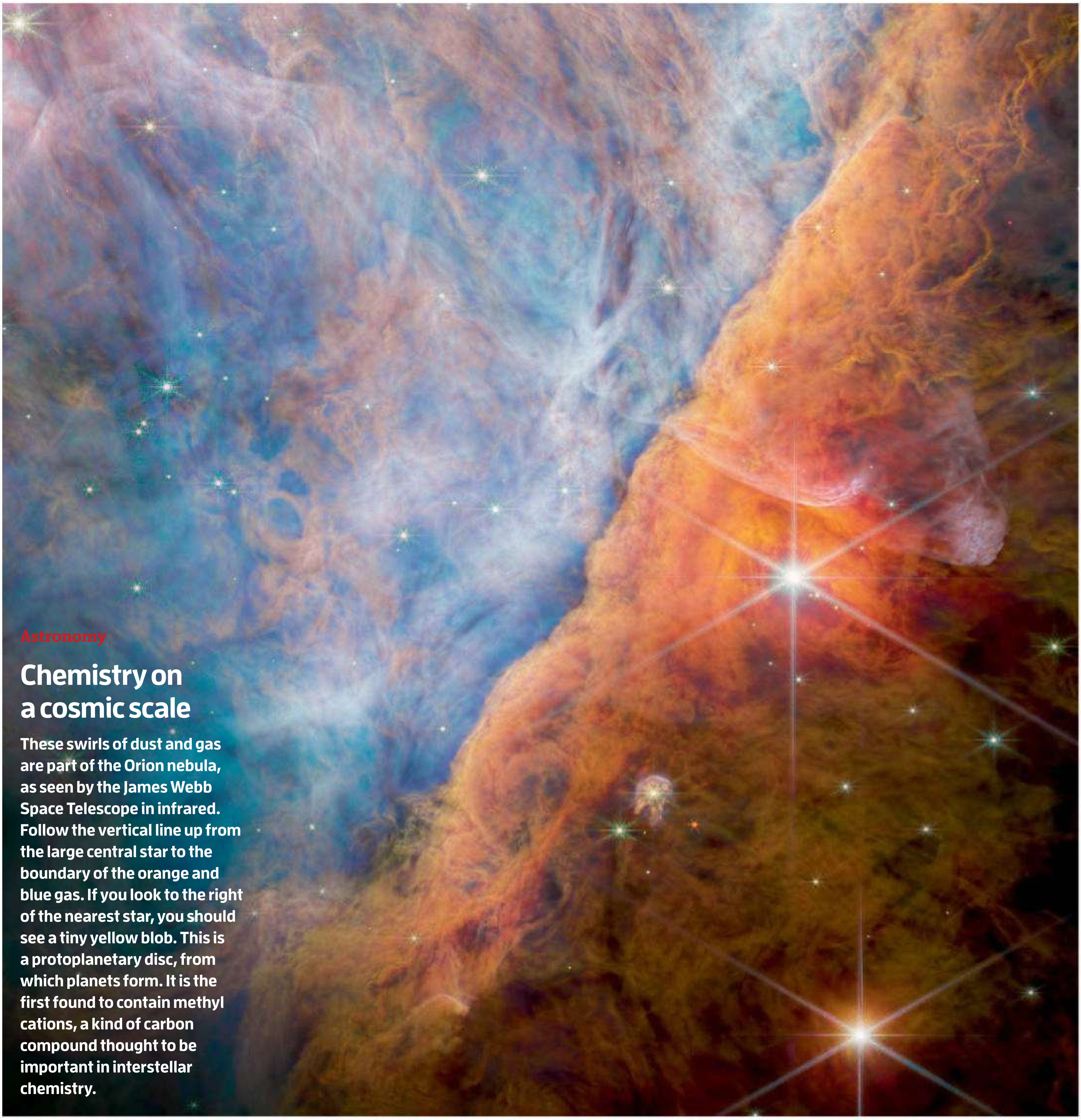


Astronomy

Chemistry on a cosmic scale

These swirls of dust and gas are part of the Orion nebula, as seen by the James Webb Space Telescope in infrared. Follow the vertical line up from the large central star to the boundary of the orange and blue gas. If you look to the right of the nearest star, you should see a tiny yellow blob. This is a protoplanetary disc, from which planets form. It is the first found to contain methyl cations, a kind of carbon compound thought to be important in interstellar chemistry.

ESA/WEBB, NASA, CSA, M. ZAMANI/PDRS4ALL ERS TEAM

Medicine

Treated before birth

A genetic condition that sees children develop a potentially fatal lack of sweat glands is one of several that can now be treated in utero, reports **Clare Wilson**

UNIVERSITY HOSPITAL ERLANGEN

Twin boys who received intrauterine protein therapy for ectodermal dysplasia

A NEW wave of medical treatments are being used to re-engineer fetal bodies, countering the effects of serious genetic conditions before a child is even born. In a landmark result, several children have been treated for a condition that causes almost no sweat glands or teeth to develop. The innovative "intrauterine protein therapy" partially restored these missing parts, the first example of a drug treatment building new anatomical structures before birth.

The approach is a twist on gene therapies being used to treat children and adults for serious conditions such as the blood-clotting disorder haemophilia and spinal muscular atrophy, a progressive and often fatal form of paralysis. Such therapies make permanent changes or additions to DNA, ensuring that cells make the correct versions of the protein involved in the condition.

While giving gene therapies before birth may be more effective, scientists have long been cautious about using medical interventions on fetuses because of the huge potential for something to go wrong. So rather than altering genes, intrauterine protein therapies involve delivering the correct version of the protein that a faulty gene is supposed to make (see "Types of fetal therapy", right).

The idea has been put into practice by Holm Schneider at University Hospital Erlangen in Germany and his colleagues. They have used protein therapy to treat ectodermal dysplasia, a condition that, in a severe form that mainly affects boys, means they have no sweat glands, very few teeth and sparse hair.

The worst aspect is the lack of sweating, as this can be fatal in children, and even adults with the condition need to ensure they don't overheat, says Schneider.

The condition is caused by mutations in the gene necessary for the formation of sweat glands, teeth and hair. The protein this gene codes for needs to be delivered between about five and seven months into pregnancy. "If we miss this window, then we will not be able to induce sweat glands later on," says Schneider. That also means the condition can't be treated by gene therapy post-birth.

> "If we miss this window during development, we will not be able to induce sweat glands later on"

His team has previously reported treating six boys with the condition, and he has now begun a formal trial. In the first six cases, five who received two or three doses of the protein were born with the appropriate number of sweat glands, while one who received a single dose has fewer glands, but he still has good heat tolerance, says Schneider.

The oldest of the treated boys are twins, now 7 years old (pictured, above), whose sweat glands are functioning well. They coped fine with a supervised trip to a sauna, Schneider told the International Fetal Transplantation and Immunology Society (IFeTIS) Conference in Edinburgh, UK, on 17 June.

The treatment also led to more teeth developing. Affected children usually have three or four teeth, all in the upper jaw. The treated boys have an average of 10 teeth in total, across both upper and lower jaws, which will let dentists fix prosthetic teeth to the natural ones, says Schneider. "That's a very big advantage."

"They have done the first intrauterine treatment of a genetic disease with a genetically focused therapy," says Anna David at University College London, who organised the IFeTIS conference. "Definitely it's a landmark."

Schneider's team delivered the protein by injecting it into amniotic fluid, which fetuses regularly swallow. The protein was linked to an antibody that the fetal gut normally absorbs well, as it is designed to take up antibodies present in breast milk.

The same technique – of fixing a therapeutic protein to this antibody – could be used to treat other conditions, says Schneider. His team is investigating turning this into a treatment for cleft palate, where the top of the mouth doesn't form properly.

In a second example of intrauterine protein therapy, Tippi MacKenzie at the University of California, San Francisco, and her colleagues have made progress treating a group of metabolic conditions that, if untreated, can be fatal in childhood. For instance, in one form, called infantile-onset Pompe's disease, babies lack a working version of an enzyme, which leads to heart damage.

The enzyme is currently given as a treatment after birth, but by then some of the damage is done. MacKenzie's team has now injected the enzyme into the umbilical cord of three fetuses, the researchers reported on 19 June at the International Conference on Prenatal Diagnosis and Therapy, also held in Edinburgh.

The team reported in December that the first child, now aged 1, has excellent heart function and is meeting developmental milestones. The other two have been born and are "doing well", says MacKenzie, although she isn't yet giving further details.

Protein therapies aren't the only example of prenatal treatment taking off. Researchers are also looking at using stem cells, which are similar to cells in an early embryo and can multiply and grow into different tissues. If stem cells without a faulty gene are given to a fetus, the aim is that they will take up long-term residence and substitute for the recipient's cells with faulty DNA.

One promising application is as a treatment for brittle bone disease, caused by mutations in the genes that make collagen, a constituent of the skeleton. In the severest versions, people have a twisted skeleton and may have several hundred bone fractures in their lifetime. "You can imagine the pain," says Lilian Walther Jallow at Karolinska University Hospital in Stockholm.

Stem cells may be a better treatment for brittle bone disease than gene therapy, because the condition can be caused by mutations affecting multiple genes, says Walther Jallow, which means each one could require a slightly different gene therapy design. However, people may need several doses of the stem cells.

In this case, the cells being used come from aborted fetuses. They are a kind known as mesenchymal stem cells (MSCs), present in many organs of the body. When injected into the blood supply, they take up residence in various tissues and turn into that tissue – including bone, animal studies have shown.

Walther Jallow and her colleagues have been using MSCs to treat brittle bone disease in young children. They have also given them to four fetuses under "compassionate use" rules that apply in desperate medical cases. They reported encouraging results for the first two individuals, who seemed to have fewer fractures and better skeletal growth than untreated children with similar mutations.

A trial is now beginning to compare results when the cells are given as several doses after birth, or in some cases prenatally as well. This has so far treated an additional three fetuses, as well as 15 children after birth, Walther Jallow reported at the IFeTIS conference, although results aren't yet available.

The first compassionate use of stem cells for brittle bone disease in a fetus was 20 years ago, yet the formal trial only began in 2020, showing how slow-going the fetal therapies field can be. Researchers want to avoid unexpected toxicities, which have happened with some gene therapies given after birth, says MacKenzie. For instance, in the early 2000s, four children being treated for a rare immune condition developed leukaemia as a result.

"We're all trying to be very cautious. But we're excited about the future"

A shadow has also been cast over the field by the 2018 scandal in which He Jiankui gene edited early embryos in an attempt to give people resistance to catching HIV. His actions led to three girls being born with permanent changes to their own cells, as well as to the "germline cells" that give rise to eggs within their ovaries, meaning that their descendants will be genetically changed too. He was jailed by Chinese authorities, but has since been released. The priority is to ensure no such further germline changes are made, says MacKenzie.

Nevertheless, with the first trials having begun for stem cell and protein therapies, and several gene therapies already approved for children after birth, MacKenzie predicts that fetal gene therapies may not be too far away. "Right now, we're probably at the inflection point," she says. "We're all trying to be very circumspect and cautious. But we're excited about the future." ▮

Types of fetal therapy

Medical conditions caused by faulty genes can be tackled in several ways:

STEM CELL THERAPY
Stem cells without the faulty gene can be given to a fetus, so they will substitute for the recipient's cells. This has helped several children with brittle bone disease and a trial is under way for alpha thalassemia, which requires frequent blood transfusions.

GENE THERAPY
Cells in the relevant part of the body can have a correctly functioning version of the gene introduced or the DNA can be changed using CRISPR "gene editing". A few such therapies for adults have reached the clinic, but in fetuses they haven't gone beyond animal tests, with the exception of the "CRISPR babies" scandal in 2018 (see main story).

PROTEIN THERAPY
Instead of editing DNA, the correct version of the protein encoded by the gene can be given to the fetus. This has been done for two medical conditions: one that causes a lack of teeth and sweat glands, and a usually fatal metabolic disorder.

JOSE LUIS PELAEZ INC/DIGITAL VISION/GETTY IMAGES

Doctors are cautious about therapies that might affect the development of a fetus

Astronomy

Euclid ready to probe dark cosmos

Space telescope set to launch on 1 July to study the effects of dark energy and dark matter

Leah Crane

THE European Space Agency (ESA) is gearing up to launch its newest space telescope, Euclid. As *New Scientist* went to press, it was scheduled to blast off from Cape Canaveral in Florida on 1 July. Euclid is designed to help solve two of the biggest mysteries in the universe: dark energy and dark matter.

These two "dark" components make up more than 95 per cent of the cosmos, but we can't see them – hence their names – and know very little about what they could be made of. Astronomers infer the existence of dark matter from the behaviour of the matter that we can see, which acts as if there is some extra source of gravity holding everything together. Dark energy has the opposite effect, causing the accelerating expansion of the universe as a whole.

Euclid has two scientific instruments: a visible light camera to measure the shape of galaxies and a near-infrared detector to measure their brightness and distance. It isn't the first space telescope to use either type of instrument, but it is intended to observe a huge swathe of space, cataloguing more than a billion galaxies across a third of the sky.

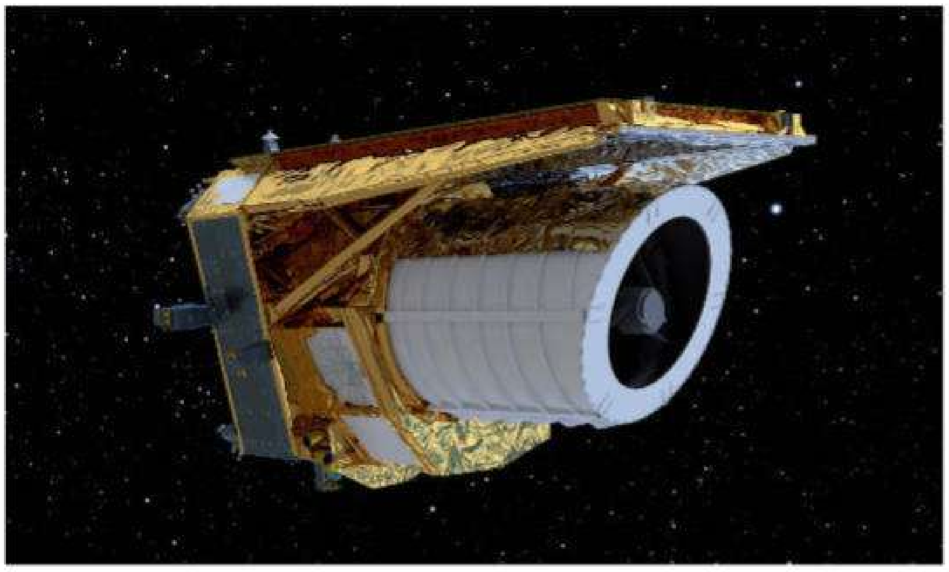
"With Hubble and the James Webb Space Telescope, those are great observatories for looking at very small regions with very high sensitivity, extraordinary detail – but it's a bit like looking at the sky through a tiny straw," says Mike Seiffert at NASA's Jet Propulsion Laboratory in California, a project scientist for Euclid. "With Euclid, we're less interested in the properties of individual galaxies and objects than we are in measuring a few properties of many, many galaxies."

Researchers will use these properties to build two types of maps of the universe. The first will use a phenomenon called gravitational lensing, in which relatively nearby matter warps and magnifies the light of objects behind it. The way this bends the apparent shapes of distant objects can tell us about the distribution of the matter acting as the lens.

The distortions are usually tiny, but the huge amount of data Euclid is expected to collect during its six-year mission should allow people to use gravitational lensing to map out the distribution of matter – including dark matter, which we can't see any other way – in the universe. This may help us figure out how dark matter behaves and what it is made of.

The other type of map uses ripples in the matter distribution of the universe called baryon acoustic oscillations. These ripples first formed as sound waves soon after the big bang, when the cosmos was a hot, roiling soup of particles and radiation. Eventually, that soup cooled and the waves froze in place, remaining as slightly more dense regions where more galaxies tended to form as the universe expanded. "Seeing how those wrinkles in the early universe propagated forward and how dark energy affected that will help us understand the evolution of the universe and, really, how the universe works," says Seiffert. ▮

An artist's impression of the European Space Agency's Euclid telescope



ESA

Medicine

3D-printed human heart chamber beats for three months

MINIATURE-sized heart chambers called ventricles have been 3D printed using live human heart muscle cells and shown to beat on their own for at least three months.

Artificial heart tissue can be made by growing heart cells in moulds or on scaffolds, but this typically only enables the construction of simple shapes like sheets or rings.

3D printing allows the creation of more complex structures. In 2019, for example, Nadav Noor at Tel Aviv University in Israel and his colleagues 3D printed a whole heart; however, it couldn't beat.

Now, Tilman Esser at the Friedrich-Alexander University of Erlangen-Nuremberg in Germany and his colleagues have used 3D printing to fabrihcate beating ventricles, the chambers at the bottom of the heart that pump blood to other parts of the body.

They made an "ink" containing live heart muscle cells mixed with collagen protein and hyaluronic acid, which give heart tissue its structure. This was then inserted via a nozzle into a supportive gel that held it in the desired shape during printing, then was melted away to leave the printed structure.

The researchers created ventricle-like structures that were 14 millimetres high and 8mm in diameter, about a sixth the size of human ventricles.

These mini chambers started to beat a week after they were printed and were still beating after 100 days. Like real hearts, they beat faster when treated with a stimulant drug (bioRxiv, doi.org/kgkb).

The team hopes to print a whole beating heart with all four chambers, but "there are many challenges in the field that come with scaling up organ models to the size of a native organ", says Esser.

For example, real-sized hearts require blood vessels to supply oxygen and nutrients. The researchers want to add a second printing ink containing vascular cells, which they hope will grow into blood vessels in the printed heart. ▮

Alice Klein

> "The ventricles were still beating after 100 days and, like real hearts, beat faster when stimulated"

Exercise

Night-time meals may help you run for longer

Carissa Wong

MARK METCALFE/GETTY IMAGES

Endurance running requires a specific type of muscle fibres

SHIFTING your mealtimes to eat later in the day and at night may boost your exercise endurance, suggests a study in mice.

Limiting your eating to within windows of six to 12 hours during daytime, without necessarily altering what or how much you eat, has been previously shown to boost weight loss, reduce harmful spikes in blood sugar levels and lower blood pressure. But now it seems night-time eating could also offer benefits, says Min-Dian Li at the Army Medical University in China.

Previous studies have shown that mice that eat only in the day – when, unlike us, they usually rest – are at greater risk of diabetes and building up fat in their livers than mice that eat at any time. There is also evidence that people who work and eat at night have an increased diabetes risk.

But Li and his colleagues have now found that mice that eat during their resting hours, the equivalent of our night, seem to do better in exercise endurance tests. "If we treat the mice with this schedule for just a short time, it has a beneficial effect on running performance," he says.

The researchers got 30 mice to eat a diet of cereal grains in either a 12-hour period when lights were on or a 12-hour period when lights were off, each day for three weeks. Sixteen other mice could eat whenever they wanted over the three weeks.

> "Switching your eating schedule for just a few months could give you an endurance boost"

Mice that only ate in the day could run for twice as long on a treadmill as mice that only ate in the night or whenever they wanted. Analysing the leg muscles of mice revealed that those fed in the daytime had more of a type of muscle fibre used in endurance running than the others, says Li.

Further analysis of muscle samples revealed that daytime eating was linked with lower levels of a protein called perilipin-5. The team then genetically edited another set of mice to lack this protein in their muscles and allowed them to eat when they liked. Putting these mice through the treadmill test and analysing their muscles revealed that lower perilipin-5 levels were indeed behind the running endurance effects (*Nature Metabolism*, doi.org/kgkw).

"As mice are nocturnal, the equivalent treatment in humans could be to eat in the night, or perhaps eat less earlier in the day and have a big dinner just before you sleep," says Li, although this still has to be tested in humans, he says.

Li says the researchers plan to look at the impact on organs beyond muscles. If people temporarily adopt night-time eating – before a big race, say – they may not experience the negative effects seen by people who do so long-term, he says.

"This might work by switching your eating schedule for just a few months – the human equivalent of three weeks in mice – or a short period, rather than for a longer timeframe, running up to when you need an endurance boost," says Li. What's more, adjusting mealtimes in this way may help older people who could benefit from greater muscle endurance, he says.

"While the results are exciting, they need to be confirmed in humans," says Juleen Zierath at the Karolinska Institute in Sweden. The mice also ate a cereal-based diet, which is "not at all the kind of diet that humans typically eat", she says, so more varied meals might have a different effect. ▮

Marine biology

Zombie worms can survive by eating shark teeth

Richard Pallardy

DEEP-sea worms feast on sharks' teeth that have fallen to the seabed.

Osedax worms are strange-looking creatures with frilly pink gills. They have no mouth or stomach, so rely on microbes living inside them to absorb collagen from bones. These "zombie worms" were discovered in 2002 on dead whales that had sunk to the sea floor.

Until now, they were thought to feed exclusively on the collagen and lipid components of bone – their Latin name means "bone eater". Traces of these worms have been discovered in fossils dating to the Cretaceous Period, suggesting that they predate the whales that they are best known for feeding on.

In 2018, to see if *Osedax* worms also eat cartilaginous fish, such as sharks and rays, which have existed longer than whales or bony fish, Greg Rouse at the University of California, San Diego, and Shana Goffredi at Occidental College in California sunk mesh bags containing the jaws of three common thresher sharks (*Alopias vulpinus*) in Monterey Bay, California. The jaws fell to a depth of about 1000 metres.

Eight months later, there were few remaining traces of the jaws, but 10 of the 40 remaining teeth had been colonised by two species of *Osedax* worms. The worms had inserted themselves through the softer roots of the teeth, indicating that they were after the collagen-rich dentine within. These zombie worms secrete an acid to penetrate bone, but hadn't dissolved the enamel on the crowns, which is harder than the bone that they typically feed on (*Journal of the Marine Biological Association of the United Kingdom*, doi.org/kgkh).

Shark carcasses "may be one of the stepping stones that keep the population going between whale falls", says Karen Osborn at the National Museum of Natural History in Washington DC. ▮

Field notes Northvolt Ett plant, Sweden

Inside the gigafactory producing the world's greenest batteries

Northvolt says its huge complex will soon produce enough batteries each year to power a million electric cars, finds **Michael Le Page**

NORTHVOLT ETT

The Northvolt Ett factory site includes a series of vast buildings

ON A journey out of Skellefteå, an industrial town in the north of Sweden, I pass several large factories. But all are dwarfed by my destination – Northvolt Ett, the first battery "gigafactory" to begin production in Europe.

"You need to see it to believe it," says Anders Thor at Northvolt, the firm behind the factory. As Thor points out, the Pentagon – the largest office building in the world and home to the US defence department – could fit into the site with plenty of room to spare.

Much of Northvolt Ett is still a building site. Wearing safety boots, I trudge across the dusty gravel to the side that has been finished – a series of enormous grey buildings where battery production is being slowly ramped up after beginning in 2021.

When complete in about 2026, Northvolt Ett will employ 4000 people and produce 60 gigawatt-hours of lithium battery cells a year, enough for a million medium-sized electric cars. Everything here is on a vast scale.

But scale isn't the factory's only claim to fame. Northvolt says that, once fully operational, its batteries will be the greenest in the world.

You have probably heard the myth that electric vehicles don't reduce greenhouse gas emissions overall. But over their lifetime, electric cars have a smaller carbon footprint than fossil-fuel ones, even where the electricity to charge them comes mostly from fossil fuel plants. However, making electric vehicles does produce more emissions than making standard cars because of battery production – and that is because the process is still largely powered by fossil fuels. "Batteries so far have been produced mainly on coal power," says Thor.

That is why this factory is in the north of Sweden where there is plenty of renewable electricity, including hydropower. The emissions per battery made here are 70 per cent lower than those made in China, says Thor, and Northvolt's aim is to get that figure to 90 per cent.

2026

When the Northvolt Ett battery gigafactory should be finished

There is no way to independently verify this claim, but simply siting a factory in Sweden rather than China would reduce the carbon footprint of a battery by 40 per cent, a recent report by the non-profit organisation Transport & Environment concluded. That is based on how much electricity comes from low-carbon sources in these countries.

At Northvolt Ett, there are separate buildings for each of the three main steps in the battery manufacturing process. It starts with the production of powders containing the raw materials that make up the anode and cathode.

In the second step, housed in two buildings more than 340 metres long and 110 metres wide, the powders are turned into slurries using giant mixers, says Northvolt's Sanna Bäckström. These are spread on huge rolls of thin foil and then dried in enormous ovens. One tiny section of these ovens is the only internal part of the factory I am allowed to photograph.

The anode and cathode are made on different sides of the building before being interfolded and placed in a cell, which is then filled with electrolyte. The process is largely automated.

Finally, there is the formation and ageing building. "It's like a cheese factory," says Bäckström. When a lithium battery is first charged, a film forms on the anode whose properties determine battery performance, so batteries are monitored for several weeks to ensure their quality.

Off in the distance, Bäckström points out the latest building to be finished, which will house the largest battery recycling plant in the world. It will recover lithium, nickel, manganese and cobalt, and supply half of the materials needed to make cathodes here.

Northvolt's efforts to make battery production greener also include buying raw materials from nearby mines where possible and a plan to use electric trucks to ferry materials to and from a harbour.

The company also has a test site for electric planes at an airport nearby and is developing energy dense lithium metal batteries specifically for aviation.

I leave Skellefteå encouraged. It is fantastic to see a company investing billions to do things at the speed and scale needed if we are to get near net zero by 2050. But as massive as it is, Northvolt Ett isn't enough. With more than 10 million cars sold in Europe every year, we still need many more battery gigafactories. ■

Michael Le Page's trip was paid for by Vargas, Northvolt's parent company

Marine biology

Dolphins 'talk' to their young in a high pitch, just like we do

Chen Ly

FEMALE bottlenose dolphins whistle at a higher pitch when they communicate with their calves, mirroring the sing-song "baby talk" used by humans.

There is evidence that some animals apart from us have special ways of communicating with their young, including zebra finches and gorillas.

Bottlenose dolphins produce a distinctive whistle unique to each individual, called their signature whistle, but it wasn't known if they adjust this to communicate with their offspring. To find out, Laela Sayigh at Woods Hole Oceanographic Institution (WHOI) in Massachusetts and her colleagues analysed the whistles of 19 adult female common bottlenose dolphins (*Tursiops truncatus*) in waters near Sarasota Bay, Florida. The whistles were recorded over a 34-year period, both with and without calves being on the scene.

When dolphins were with their offspring, they produced whistles with a higher frequency, or pitch, and a wider range of frequencies than at other times (*PNAS*, doi.org/gsdpd3).

"The subtle shift in the highest frequency that the dolphins use mirrors the pitch shifts we see in humans," says team member Frants Jensen at WHOI.

"I would be really interested to see whether dolphins also change their whistles when interacting with babies of others, which is what happens in humans," says Julie Oswald at the University of St Andrews, UK.

As in humans, these modified vocalisations may promote vocal learning in dolphins, says Jensen.

Studying how animals communicate with young could provide insight into the evolutionary history behind vocal learning in animals and, ultimately, language in humans, says Sayigh. ▮

Earth

Magma plumes may explain gravity hole in the Indian Ocean

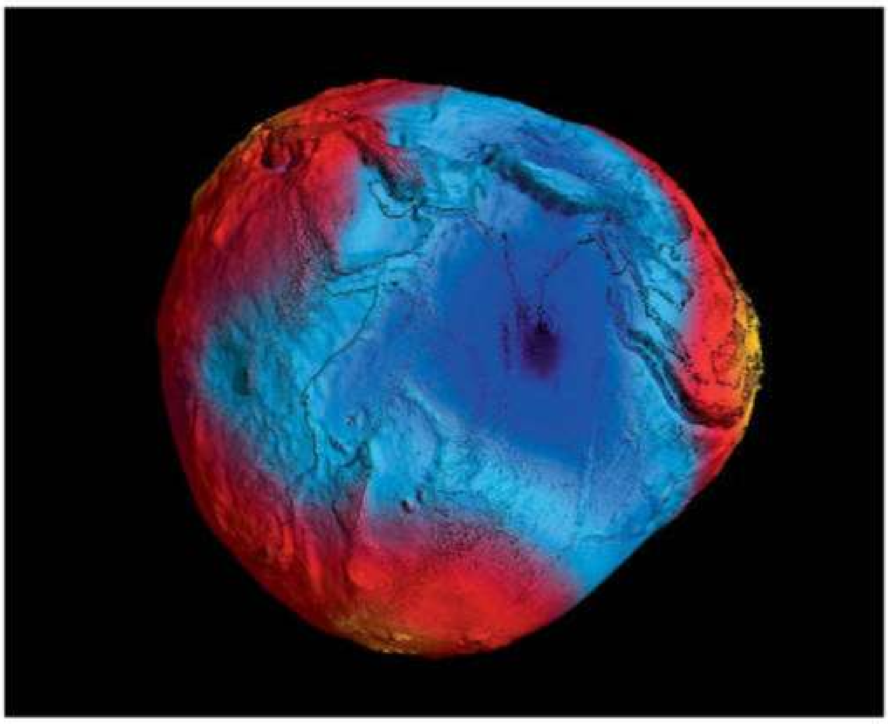
James Dinneen

THE area of Earth with the lowest relative gravity is located just south of India. This gravity "hole" may be due to low-density plumes of magma disturbed by the sinking slabs of a former tectonic plate.

Neither Earth nor its gravitational field are a perfect sphere. Because gravity is proportional to mass, the shape of the planet's gravitational field depends on the distribution of mass within it. One way of representing this is to imagine Earth's surface covered by a calm ocean: the variation in the planet's gravitational field would create bulges and depressions in the water, corresponding to areas of more and less mass. The resulting shape, known as a geoid, appears knobbly and irregular (see image, below).

The lowest point on Earth's geoid is a circular depression located in the Indian Ocean that dips 105 metres below average sea level. Geophysicists have long debated the cause of this low point, says Himangshu Paul at the National Geophysical Research Institute in India.

Blue shows low gravity and red is high gravity on this geoid map of Earth



ESA/HPF/DLR

Geoid lows elsewhere are due to deformations at the boundary between Earth's core and mantle, and structures within the mantle. But these don't explain the Indian Ocean's extreme low, says Paul. "It's the lowest in the world, so there should be a reason."

Debanjan Pal at the Indian Institute of Science and his colleagues simulated 19 scenarios for the movement of tectonic plates and changes in the mantle over the past 140 million years. In each simulation, they varied parameters that affect the formation of plumes of magma in the mantle beneath the Indian Ocean. They then compared the shape of the simulated geoids with Earth's actual geoid as seen by satellites.

In six of the simulations, the shape and amplitude of the Indian Ocean geoid low closely matched the observed low. In each of these simulations, but not the others, the low was flanked by plumes of hot, low-density magma (*Geophysical Research Letters*, doi.org/gscsrp). The plumes, in combination with the surrounding structure of the mantle, can explain the shape and amplitude of the geoid low, says Pal. "To match the exact shape you have to have the plumes."

"The geoid low in the Indian Ocean is basically just this hole where there is nothing"

Pal says these simulations also suggest a new explanation for why the plumes are present. As the Indian plate broke off from the supercontinent of Gondwana to collide with the Eurasian plate, the Tethys plate that formed an ocean between them was subducted into the mantle. Over tens of millions of years, slabs of the Tethys plate sank, churning up a region of hot magma beneath east Africa, generating the plumes.

Paul, however, says there isn't clear seismographic evidence that the plumes from the simulations are actually present beneath the Indian Ocean, and there may be other factors behind the geoid low, such as the positions of the ancient Tethys slabs. "In simulations, it is not possible to exactly mimic nature," he says.

Bernhard Steinberger at the German Research Centre for Geosciences says the new model shows the geoid low has more to do with the plumes and slabs that surround it than any particular structure beneath the low itself. "It's basically just this hole where there is nothing," he says. ▮

Conservation

Endangered butterflies are being sold for high prices on eBay

Jason Arunn Murugesu

TENS of thousands of butterflies are sold on eBay a year and endangered species covered by trade restrictions command some of the highest prices, an analysis has found.

Zhengyang Wang at Harvard University and his colleagues monitored eBay sales of dead butterflies for a year from September 2020 by automating the search of 150,000 butterfly names on the site. The team recorded more than 50,000 transactions involving 3767 species, close to a fifth of all known butterfly species.

Only 2 per cent of the butterflies sold were considered endangered, but they include four of the top 10 most expensive species in the analysed transactions. For example, a male and female pair of Ludlow's Bhutan swallowtails (*Bhutanitis ludlowi*) originating in India sold for $8998.

"Just like in the world of all collectibles, rare things are more expensive," says Wang.

The vast majority of the butterflies sold on the site originate from South-East Asia and Central and South America, but appear to be sold by traders in Europe and the US, says Wang.

People are using eBay to add to their collections of butterfly specimens

LEO BILD/ALAMY

Laws vary between countries, but many require permits to collect butterflies or ban the collection of the insects from certain protected sites, says Blanca Huertas at the Natural History Museum in London. The sales of some endangered butterflies, as listed on the CITES trade database, require permits or are prohibited outright, says Huertas. Wang says his team didn't see any permits displayed on the eBay listings.

$8998

The price a pair of Ludlow's Bhutan swallowtails sold for

The researchers also asked 200 people to assess the aesthetic qualities of traded insects. The ratings for each species correlated with trade volumes (*Biological Conservation*, doi.org/kf9n).

"Normally, you would expect that collectors just want the 'rare' specimens," says Wang. "But our study shows that a butterfly collection is more like a home decoration piece rather than collecting a piece of abstract modern art – people are buying butterflies because they are beautiful."

The findings suggest that two types of people buy butterflies online: professional collectors who will pay more for the rarest species and hobbyists who want the prettiest ones, says Wang.

Wang suggests that butterfly trading could be used to fund conservation efforts to protect their habitats. "If done correctly, it's a win-win for stakeholders and the environment," he says. Butterflies aren't collected to extinction, he says, because they reproduce so much, it is habitat destruction that wipes them out.

But Tim Shreeve at Oxford Brookes University, UK, says further legitimising butterfly trade is risky. "This type of trade could lead to more exploitation, with people incentivised to collect the rarest type of butterflies, potentially threatening the insects' existence," he says. "Moreover, you have to actually make sure that the money goes to the Indigenous population collecting these butterflies and not profiteering middlemen."

In a statement, an eBay spokesperson said the site has strict policies and guidelines to regulate the listing of animal products and the firm promotes the protection of wildlife.

"To reinforce our regulations, we have global teams dedicated to upholding standards on our marketplace. eBay is a founding member of the Coalition to End Wildlife Trafficking Online and we work alongside organisations such as WWF and IFAW [the International Fund for Animal Welfare] to continually update our measures," the spokesperson said. ▮

Technology

Tentacle robot can bend through pipes and unscrew bolts

Karmela Padavic-Callaghan

A TUBULAR, soft robot controlled by light can pump liquids, unscrew bolts and travel through pipes. The robot can also be designed to bend in the direction of a light source, like a plant tilting towards the sun.

In some materials, molecules can gain energy from light, which makes the material expand or contract. Jiu-an Lv at Westlake University in China used this effect to create prototypes of a soft robot made up of a tube 15 to 40 millimetres long.

He and his colleagues wound filaments of a light-sensitive elastic material into an arrangement inspired by an elephant's trunk, which has muscle fibres layered so it can take different shapes depending on which fibres tense.

Because the tubular robot's fibres respond to light, it took on different shapes when illuminated with light of different frequencies and intensities.

In one experiment, the researchers filled the robot with a liquid and connected it to a tube that led to a raised container. Using light to make the robot contract pumped the liquid up to the container. In another, they slid the robot through a curved pipe that had a bolt at the bottom. When the bendy body connected to the bolt, the researchers illuminated it to make it twist and unscrew the bolt.

Lv and his colleagues also worked out how to wind the light-sensitive fibres into the shape of an artificial plant that combined the bending and twisting motions to move towards light. When the light was very intense, the robot could also tilt away from it (*Science Advances*, doi.org/kgjn).

Shengqiang Cai at the University of California, San Diego, says this adaptive behaviour is impressive and may be useful for developing devices that can keep adjusting themselves as they absorb and collect the energy of the sun. ▮

Environment

Amazon deforestation has slowed down since Lula took over in Brazil

Luke Taylor

ALMOST six months into his second spell as president of Brazil, Luiz Inácio Lula da Silva has begun to rein in the rampant destruction of the Amazon that was let loose by his predecessor, Jair Bolsonaro.

The first big reduction in forest clearing came in April, when Amazon deforestation fell 68 per cent compared with the same month last year. May saw a smaller drop of 10 per cent, according to Brazil's National Institute for Space Research. Overall, there was a 31 per cent fall in deforestation in the first five months of 2023 compared with this period in 2022.

Between 2019 and 2022, Bolsonaro publicly encouraged development in the Amazon, watered down environmental protections and gutted ministries responsible for conserving the rainforest. During his presidency, the amount of Amazon forest lost increased 59.5 per cent on the previous four years.

Since taking office in January, Lula has restored funding for environmental protection and has reappointed officials. From January to May, the environment agency Ibama placed commercial embargoes on 2255 farms on illegally deforested land and imposed 2 billion reals ($406 million) in fines for environmental crime, which is up 160 per cent on the average yearly sanctions during Bolsonaro's term.

Deforestation alerts – which occur when satellites detect changes in forest cover – began to decline shortly after enforcement efforts were ramped up, says Suely Araújo at Brazil's Climate Observatory.

ALAN CHAVES/AFP VIA GETTY IMAGES

Miners were evicted from this illegal camp in the Amazon in February

In June, Lula outlined a plan to implement his pledge of ending illegal deforestation by 2030. He promised that intelligence agencies would do more to identify environmental crime and he would set up a registry to monitor the management of important forests.

Brazil has also rebuilt relationships with international partners and revived the Amazon Fund, which has received donations worth hundreds of millions of dollars from foreign governments. A committee in Brazil's Senate is currently working on a plan that would allow the country to profit from protecting tropical forests by selling carbon credits to other nations.

"Lula's plan to fight climate change could be the most ambitious in the world as it combines ways to combat deforestation, while also providing livelihoods for those who clear forests," says Erika Berenguer at the University of Oxford.

Lula aims to take back half of the protected lands being illegally exploited for logging, farming, mining and other activities.

The next few months will better reveal how much the surge in deforestation under Bolsonaro will spill over into Lula's term. The dry season begins in the Amazon in July and many plots that were partially cleared under the previous administration could be burned for cattle ranching, says Berenguer. ▮

Space

The centre of our galaxy has a strange no-entry zone

THERE is an unexplained "zone of avoidance" for stars near the centre of the Milky Way. Stars at any given distance from the supermassive black hole at the galactic centre, called Sagittarius A*, should have a random distribution of shapes to their orbits, but one group of stars doesn't fit that pattern.

It comprises about 200 stars near Sagittarius A* called S-stars, and their very existence is strange because the environment there is very hostile. Andreas Burkert at University Observatory Munich in Germany and his colleagues examined the orbits of 50 or so of these stars.

They found a correlation between each star's distance from the galactic centre and the shape of its orbit – the closer a star is to the middle of the galaxy, the more stretched out, or eccentric, its orbit. But in the area immediately around Sagittarius A*, there are no stars with circular orbits, a phenomenon the researchers call a zone of avoidance (arXiv, doi.org/kf68). If those stars existed, they would be the easiest to spot, so it is unlikely that this anomaly is a result of a problem with the data.

"It's as if something forbids stars from going into the zone, or the ones that do go into the zone get destroyed," says Burkert. Given that there are plenty of stars close to Sagittarius A*, there is no known reason why at least some of the stars in the area shouldn't have circular orbits.

"It's as if something forbids stars from going into the zone, or the ones that do go in get destroyed"

"It seems that the presence of a supermassive black hole creates an underlying mechanism that forces objects to arrange in a non-randomised pattern," says Florian Peissker at the University of Cologne in Germany. "The big and important question is: why?"

"We don't really know what it is yet," says Burkert. "I think that's the most exciting part." ▮

Leah Crane

Analysis Computing

Which quantum computer is the most powerful? IonQ has become the latest firm to claim its forthcoming device is better than any other. But how do you benchmark a quantum computer, asks **Matthew Sparkes**

QUANTUM computing firm IonQ has sold a device that it claims will be able to outperform any classical supercomputer or other quantum computer in the world – but the machine has yet to be built. So who currently claims the quantum crown?

Comparing quantum computers made using a variety of technologies by different companies is far from an exact science. One measure is the number of qubits, or quantum bits, a computer has, with more bringing theoretically higher performance.

This is a crude measure that doesn't take into account how fast the machine carries out operations, how interconnected the qubits are or how reliable their calculations can be.

So IonQ has created a metric called algorithmic qubits (AQ), which the firm claims is the most holistic measure yet, taking into account the number of qubits and how interconnected they are. In May, it claimed that its machine Aria had reached a record AQ of 20 – making it "the most powerful quantum computer in the industry".

Since then, IonQ says it has made a computer with an AQ of 29, and is now developing a machine with an AQ of 35 and then 64 for commercial quantum hub QuantumBasel in Switzerland. QuantumBasel says it will use them to solve problems in pharmaceuticals, chemistry and finance. IonQ says it will ship the machines in the next couple of years.

IonQ claims that the AQ 35 machine will be on the verge of exceeding the capabilities of quantum hardware being simulated on standard computers, while the AQ 64 one will be capable of calculations that even the best current classical supercomputers can't simulate. "If an AQ 64 universal quantum computer were available today, it would certainly be the most powerful quantum computer out there," says IonQ co-founder Christopher Monroe.

How do these yet-to-be-built devices measure up against competitors? Monroe says the AQ 35 machine is likely to have 35 qubits, and that the AQ 64 one could have anything from 96 to 1024. People racing to gather more qubits is mostly recognition that the qubits have low fidelity and lots are needed for error correction, says Monroe.

> **"The only metric that can't be gamed is what problems the machine can actually solve"**

The current qubit record holder is IBM's Osprey computer, with 433, but IBM hasn't yet said how that performs. Its previous device, the 127-qubit Eagle, has won a head-to-head with a supercomputer at the Lawrence Berkeley National Laboratory in California. Google has also claimed its machines can beat supercomputers in some scenarios.

It isn't possible to make an AQ comparison across firms because they don't publicly release AQ figures. IBM wasn't able to provide *New Scientist* with AQ measurements before publication, while Intel and Google didn't respond when asked.

Is AQ a meaningful comparison? Josh Nunn at Orca Computing says it makes sense, but that it suits IonQ's approach to quantum computers – creating a string of qubits made of trapped ions that can each talk to any other qubit.

"IonQ is highly focused on applications that will derive value for users and customers, and AQ nicely captures the structure of the algorithms that we are investigating with customers," says Monroe.

Scott Aaronson at the University of Texas at Austin says inventing metrics isn't helpful. "The suspicion naturally arises that each company will invent and advocate a benchmark on which its devices are the best," he says. "The only metric that can't be gamed is what problems you can actually solve." ▮

Space

Milky Way could hold thousands of stars from another galaxy

ROBERT GENDLER/ESA

Andromeda, our nearest galactic neighbour, may have gifted us some of its many stars

OUR galaxy might contain thousands of stars that were expelled from neighbouring galaxy Andromeda, and they may even have brought planets with them.

Some stars in the Milky Way are moving so fast they can escape our galaxy's gravity, which raises the question of whether such stars could exist in, and leave, other galaxies. Now, Lukas Gülzow at the Karlsruhe Institute of Technology in Germany and his colleagues have investigated how many stars from Andromeda, which is around 2.5 million light years from Earth, could be in the Milky Way.

The researchers focused on stars that were once part of a pair that got too close to a supermassive black hole – one is absorbed while the other is shot out at high speed. They simulated 18 million stars ejected this way, from the black hole at Andromeda's centre, and tracked the trajectories according to the gravitational pull of both galaxies.

"Only a small number, around 0.08 per cent of them, can make it to the Milky Way, and even less would be measurable," says Gülzow.

Assuming that Andromeda produces as many high-velocity stars as the Milky Way does, the team calculated that anywhere from 12 to 3909 of them may be in our cosmic neighbourhood today (arXiv, doi.org/kf52). If the number is towards the upper range, this may be enough for the Gaia spacecraft – which tracks about 1 per cent of stars in the Milky Way – to find them. The stars would have a telltale direction and speed pointing away from Andromeda, says Gülzow.

Such stars could bring planets along for the ride, says Gülzow, assuming the worlds survive being blasted by a black hole.

"It's an interesting idea and there very likely are indeed hypervelocity stars in the Milky Way coming from Andromeda and from other galaxies," says Kareem El-Badry at Harvard University. ▮

Alex Wilkins

Technology

Eye reflections used to make 3D models of what you see

Chris Stokel-Walker

YOUR eyes reveal more than you may think, because computer-vision technology can now reconstruct 3D images of a scene from the reflections on someone's eyeballs.

Jia-Bin Huang and his colleagues at the University of Maryland, College Park, developed a computer-vision model that takes between five and 15 digital photographs from different angles of an individual's face while they look at a scene, then reconstructs that scene from the reflections in their eyes.

The method adapts a technique called neural radiance fields (NeRF), which uses neural networks to determine the density and colour of objects the computer "sees". NeRF usually operates by directly looking at a scene, rather than viewing one reflected in a person's eyeballs.

Huang's version builds the scene by extrapolating from a square of, on average, 20 by 20 pixels in each eye. The method can produce what the researchers call "reasonable" results in replicating the real-life objects, but they are blurry because of the difficulty of rendering the shape of the cornea – the clear outer layer at the front of the eye.

When tested on clips from Miley Cyrus and Lady Gaga music videos, the technique picked out the rough shape of objects seen in the singers' eyes, but struggled to reconstruct details (arXiv, doi.org/kf92).

The study builds on research from the mid-2000s. "That work made a splash in showing how the surface of the cornea could be used as an approximation of a curved mirror to create panoramic images," says Serge Belongie at the University of Copenhagen, Denmark.

"The new work extends this concept to the task of 3D reconstruction," says Belongie. "The results are quite impressive and will make people – once again – think twice about what they're revealing when they are photographed." ▮

Microbiology

Hadza hunter-gatherers have hugely diverse gut microbiomes

Jason Arunn Murugesu

MORE than a thousand novel microbe species that inhabit the gut have been discovered in the Hadza hunter-gatherer community in Tanzania. These contribute to a gut microbe diversity that is much greater than that of people in California, showing how industrialisation might have reduced the variety of microbiomes.

Matthew Carter at Stanford University in California and his colleagues genetically sequenced 351 faecal samples from 167 Hadza people to gain a better sense of how lifestyle affects our gut microbiomes.

"We know that our gut microbiome is critically important, for example in dictating aspects of our biology, our immune status and our metabolism," says team member Justin Sonnenburg, also at Stanford University.

The researchers used ultra-deep metagenomic sequencing, a type of analysis that gives an idea of the species present and their potential functions. They compared this with results from the gut microbiomes of 12 people in California and 56 people in Nepal from a range of communities.

A disproportionate amount of microbiome sequencing has focused on Western populations, says Sonnenburg. "Attention hasn't been paid to other populations and lifestyles. We wanted to help fill that gap."

The gut microbiomes of the people in the Hadza community were far more diverse that those of people in California and Nepal. The researchers found 730 species in the microbiomes of the average Hadza participant, more than twice the total number of the average Californian involved in the study – at just 277. Nepalese foragers had 317 species, on average, and Nepalese farmers had 436 (*Cell*, doi.org/kf5z).

KAIRI AUN/GETTY IMAGES

The Hadza lifestyle may be behind their wide variety of gut microbes

The researchers also discovered species in the Hadza microbiomes that had never been seen before. "The novelty in some cases is quite striking," says Sonnenburg.

1200

Number of new microbe species seen in Hadza gut samples

The team found about 1200 new species of single-celled microorganisms in the guts of the Hadza participants. Until now, there had only been about 4500 human gut species described, says Sonnenburg.

Differences in gut flora diversity can have implications. Studies suggest that people with less diverse microbiomes are less healthy, says Sonnenburg. "[People with] metabolic syndrome, inflammatory diseases, inflammatory bowel diseases all have low-diversity gut microbiomes."

The researchers are unsure if the microbiome differences they found are due to diet or highlight a wider impact of industrialisation.

The Hadza people eat far more fibre than people in the West do, says Sonnenburg. This comes from a range of sources, including tubers, baobab fruit and berries, he says.

Studies of ancient faecal samples suggest that the Hadza gut microbiomes have more in common with people in those cultures than those of people in industrialised countries today, says Carter.

The work highlights the importance of protecting the microbiomes of Indigenous peoples, says James Kinross at Imperial College London. "If we don't, the consequence will be a continued escalation in the burden of Western non-communicable diseases experienced by sub-Saharan African populations." ▮

Archaeology

The earliest Neanderthal art

Symbols have been found carved on the walls of a cave in France that was inhabited by Neanderthals before being sealed off at least 57,000 years ago, discovers **Michael Marshall**

NEANDERTHALS used their fingers to carve symbols into the wall of a cave in France at least 57,000 years ago. The engravings are some of the oldest known examples of Neanderthal art and are possibly the very oldest.

"The engravings could only have been made by Neanderthals," says Jean-Claude Marquet at the University of Tours, France. They are the only hominins to have left artefacts in the cave and the entrance was sealed by sediments until modern times.

La Roche-Cotard cave is in the Loire valley and consists of four consecutive chambers. It has been excavated on and off since 1912, with the most recent round beginning in 2008.

Neanderthals lived in the front chamber and entered the second and third, says Marquet. Excavations have unearthed many "Mousterian" stone tools, which are associated with Neanderthals and not *Homo sapiens*.

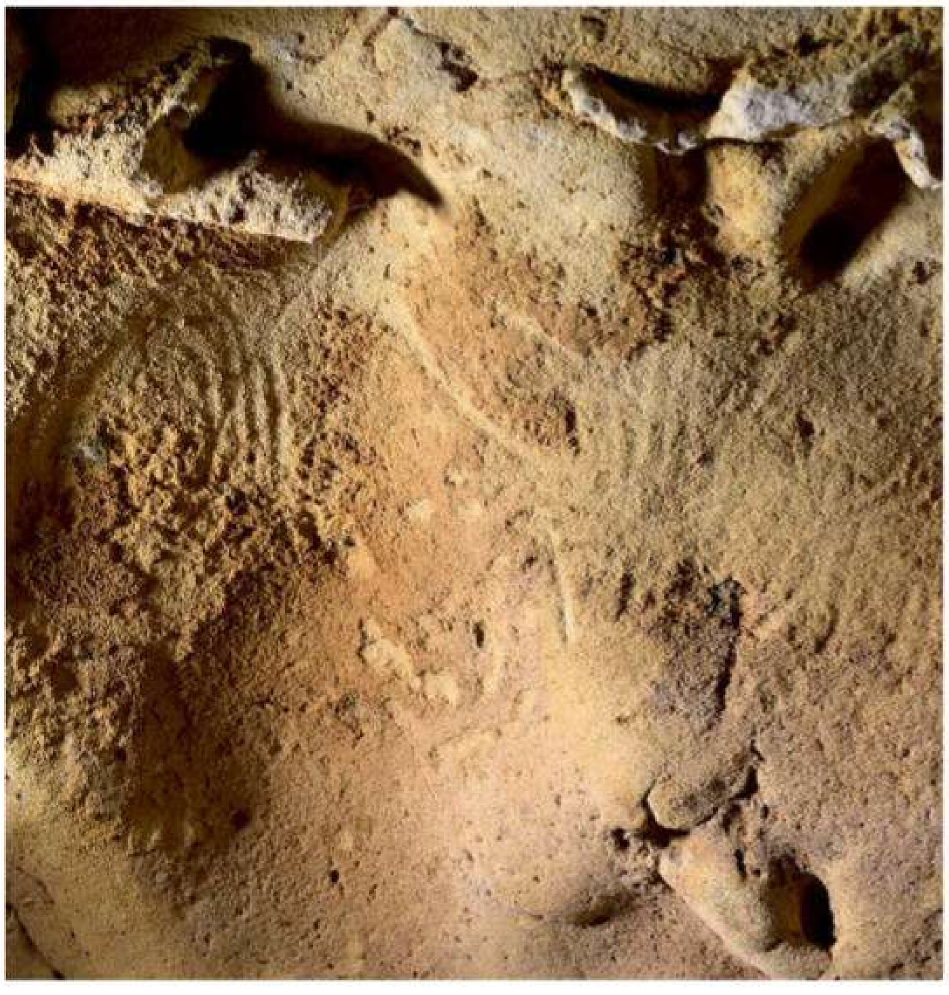
The walls of the third chamber are made of soft rock. Here, the team found eight panels covered with markings. These include many lines traced by fingers: often straight lines, but sometimes circles or ovals. Some seem to be arranged in larger patterns. One panel has a cluster of more than 100 dots. A subgroup of the engravings was made with tools like flint and antler rather than with fingertips.

It isn't clear whether the engravings "represent symbolic thinking", Marquet and his colleagues write in their paper. "Interpretation and meaning are very complicated [for us] to imagine," says Marquet.

The attribution of the engravings to Neanderthals, not modern humans, rests partly on the distinctive Mousterian tools found in the cave and partly on the timing. Marquet's team dated sediments from the cave entrance to at least 57,000 years ago, and probably around 75,000 years ago. This means the entrance was sealed around that time (*PLoS One*, doi.org/kf5w).

Neanderthals lived in Europe and parts of Asia for hundreds of thousands of years. They disappeared about 40,000 years ago, not long after modern humans began arriving in Europe in large numbers around 45,000 years ago, following their emergence from Africa. This is long after the cave was sealed.

"It's well dated," says Paola Villa at the University of Colorado in Boulder. "The fact they're all Mousterian materials suggests that they are right."



Engravings made by Neanderthals in La Roche-Cotard cave, France

JEAN-CLAUDE MARQUET, CC-BY 4.0

While many examples of prehistoric art are known from Europe and elsewhere, most are from the past few tens of thousands of years, and have been attributed to *H. sapiens*. Claims of Neanderthal art have been controversial. Strong evidence finally emerged in 2018, when researchers demonstrated that art found in several Spanish caves was more than 45,000 years old, and in some cases over 60,000 years old.

> "Markings include many lines traced by fingers: often straight lines, but sometimes circles or ovals"

The story has since become more complicated by evidence that modern humans intermittently entered Europe earlier than 45,000 years ago. Some briefly lived at Grotte Mandrin in France about 54,000 years ago and others were in Greece 210,000 years ago.

Nevertheless, on the balance of probabilities, Neanderthals are likely to have been responsible for the engravings, says April Nowell at the University of Victoria in Canada. "I have no trouble in accepting these as hominin-produced digital tracings and no trouble accepting that it dates to a period where only Neanderthals were in the region."

The engravings add to the growing evidence of Neanderthals producing symbols and symbolic artefacts. Back in 2003, Marquet and his colleague Michel Lorblanchet at the French National Centre for Scientific Research described an artefact from La Roche-Cotard: a piece of flint with a bone splinter driven through it, which they interpreted as an attempt to represent a face. More recently, a symbol like a hashtag was found in Gorham's cave in Gibraltar, which was probably made by a Neanderthal.

Clearly, some Neanderthals engaged in these behaviours, says Nowell. "But I do find it interesting that all of these examples seem to be one-offs in a way." There are no other known Neanderthal sites with engravings like those in La Roche-Cotard or Gorham's cave – whereas prehistoric art by *H. sapiens* is more common and contains repeating elements.

In the same way that people doodle shapes in sand on a beach, Neanderthals may have created symbols with no shared meaning, says Nowell. "I think we don't yet have that kind of community-level symbolic behaviour."

It may be that modern humans picked up some symbolic Neanderthal behaviours and developed them, says Villa. "There is clear evidence that they interbred," she says, so maybe they also learned from each other. ▮

Space

Comet splits after being heated by sun

A COMET from the outer region of our solar system has been observed splitting in two as it made its way past the sun.

In 2020, Comet C/2018 F4 was seen breaking up by amateur astronomers, but how it happened was unknown. Man-To Hui at the Macau University of Science and Technology in China and his colleagues have now taken a closer look with several telescopes.

They say the comet may have had two "lobes" connected by a neck. Heating of the comet's surface by the sun as it neared the centre of the solar system probably ejected material that caused it to spin and split in two. The two halves, each some 4 kilometres across, are continuing to separate and are now about 400,000 kilometres apart (arXiv, doi.org/kf59). **Jonathan O'Callaghan**

Health

Knee brace aids healing of ACL tears

THE vast majority of torn anterior cruciate ligaments (ACL) can heal themselves with the help of a specialised knee brace, a small study has found.

A ruptured ACL is a common sports injury that is usually treated with reconstructive surgery to replace the torn ligament. Stephanie Filbay at the University of Melbourne in Australia and her colleagues have tested a knee brace designed to promote healing by reducing the gap between the ligament's two torn ends.

The study included 80 people with complete ACL ruptures. Ninety per cent had signs of ACL healing after three months of wearing the brace. MRI scans showed their ACLs regrew to form one continuous length (*British Journal of Sports Medicine*, doi.org/gsc783). **Clare Watson**

KARYN HONOR/ALAMY

Animals

White spots help monarch butterflies go long distances

MONARCH butterflies with larger white spots on their wings are more successful at migrating long distances. It is unclear how the spots help the butterflies, though.

Some populations of monarchs (*Danaus plexippus*) travel up to 4000 kilometres from Canada and the US to the forested mountains of Mexico, where they settle in for winter hibernation.

Migratory monarchs have white spots framing their orange-and-black wings, while closely related butterflies that don't migrate lack them altogether.

That led Andy Davis at the University of Georgia in Athens and his colleagues to investigate what role the spots may be playing.

They analysed images of more than 400 monarch wings in different stages of the insects' autumn migration from north to south. The most successful migrants had about 3 per cent less black and 3 per cent more white on their wings (*PLoS One*, doi.org/gsc6fz).

"It's hard to see with the naked eye, but for the monarchs, that might make the difference between failure and success during the long flight," says Davis. "We were pretty shocked at that."

They also examined specimens from museums and six other closely related species, revealing that migratory monarchs have larger spots than their cousins that stay put all year round.

The researchers suspect that the white spots limit the absorption of sunlight and radiation. The resulting difference in temperature between light and dark areas of their wings could change how air flows in a way that reduces drag and boosts aerodynamics, although this has yet to be investigated. **Corryn Wetzel**

Really brief

QIBBOT

Robots fast enough for fighting games

Remotely operated one-armed boxing robots, inspired by the 2011 movie *Real Steel*, can respond to a person's movements in as little as one-hundredth of a second. The QIBBOTs, made by Qibo Robot Company in China, could also find industrial uses in situations where quick reactions are needed.

Worms use static to hitch a lift on bees

Bees accumulate an electrical charge as they fly, and experiments show that *Caenorhabditis elegans* nematode worms can exploit this to jump through the air and hitch themselves a ride. The 1-millimetre-long worms can leap 1.26 millimetres upwards onto a bumblebee (*Current Biology*, doi.org/gsc53d).

Strong and easily removed sticky tape

Laser-cutting three sides of a rectangle in a repeating pattern along sticky tape, a method inspired by kirigami, the Japanese art of paper cutting, makes it 60 times stronger, as well as being easy to peel off. Pull it one way and it comes off easily, but it resists when pulled the other (*Nature Materials*, doi.org/kf9s).

New Scientist
Events

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The columnist **Graham Lawton** on farming's tension with nature p22

Aperture A garden-planning AI designed to safeguard insect pollinators p24

Letters Synaesthesia can be put to practical use too p26

Culture Simple questions about maths hint at its complexity p28

Culture columnist *Star Trek: Resurgence* leaves **Jacob Aron** underwhelmed p30

Comment

The real threat from AI

Claims about the existential risk of artificial intelligence are frightening – but not because they are true, argues **Mhairi Aitken**

SIMONE ROTELLA

IN RECENT months, there has been a flood of claims that superintelligent artificial intelligences could one day lead to the destruction of humanity. Sam Altman, CEO of Open AI, has said the technology could lead to "lights out for all of us", while AI pioneer Geoffrey Hinton resigned from Google citing his fear that AI constitutes a threat to the future of humanity. What's more, the Center for AI Safety has published a statement on the risk of extinction the technology poses.

These claims are scary – but not because they are true. They are scary because they are significantly reshaping and redirecting conversations about the impacts of AI and what it means for AI to be developed responsibly.

The narrative that AI might one day develop superhuman intelligence and pose a threat to humanity is a familiar plot line of movies, and has firm roots within the public image of AI. This narrative has always been close at hand in media reporting, but 2023 has proven to be the year that it also found its way into policy and regulatory discussions around AI.

This is troubling, as little to no evidence is given to substantiate the emotive and sensational claims being made, and the limited evidence that is pointed to typically doesn't stand up to scrutiny. For example, claims that large language models are demonstrating so-called emergent properties (abilities which they were not trained for but which have somehow emerged) typically centre on unanticipated – but nevertheless explainable – functions of the models. When Alphabet CEO Sundar Pichai claimed Google's Bard chatbot had responded to prompts in Bengali despite not being trained to do so, the more plausible explanation came from ex-Google employee Margaret Mitchell, who pointed out Bard's development included incorporating aspects of its forerunner PaLM, which had Bengali in its training data.

This is yet another reminder that AI models only do what they are programmed to do. Claims of emergent properties are being used to deflect calls for transparency and to close down discussions of developers' responsibilities.

The loudest voices shouting about existential risk are coming from Silicon Valley. This may seem at odds with big tech's stake in driving innovation and investment in AI, yet these narratives protect its interests by diverting attention away from big tech's current actions to instead speculate about hypothetical future abilities of AI.

By suggesting AI might develop its own intelligence, the focus shifts to how we might hold the technology accountable in the future, rather than how we can hold big tech accountable today. All of this creates an illusion of inevitability, suggesting we are observing the evolution of AI, rather than a series of conscious and controllable decisions by organisations and people.

It is important to consider not just what is being said, but who is being listened to. We have seen Altman being warmly greeted by regulators across Europe, while the voices of people who are negatively affected by AI are barely heard. This is symptomatic of what academic Kate Crawford has termed AI's "white guy problem": claims of existential risk are largely coming from affluent white men in positions of power, those least likely to experience the harms of AI today (but with most responsibility for causing them).

We are at a critical moment where governments are grappling with the challenges of effectively regulating AI. Countering narratives of superintelligence and existential risk is crucial to ensure that these discussions centre on the voices of affected communities, rather than the vested interests of big tech, and that they engage with the real impacts of AI, rather than the fantasy and distraction of artificial general intelligence. ▮

Mhairi Aitken is an ethics fellow at The Alan Turing Institute, UK

No planet B

Don’t mention the R word

Rewilding is becoming a taboo term among farmers, although they are happy to talk about “nature-friendly farming”, finds **Graham Lawton** on a trip to Wales

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn’t Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

MY LATE uncle was a sheep farmer in north Wales and I have happy memories of visiting his farm in Snowdonia as a child. I wasn’t much interested in farming back then, but these days I find it fascinating. Producing enough food to feed a growing global population is one of the most destructive activities we impose on the natural world, a massive driver of climate change and a major threat to biodiversity.

“Biodiversity is, on average, faring very badly indeed,” says Andrew Bamford at the University of Cambridge. “And while other drivers of biodiversity’s decline often attract more attention, the greatest source of threat to the natural world is, and for a long time will remain, the prosaic but pervasive challenge of how to meet rising human demand for food.”

Turning natural habitat into farmland and further degradation of existing farmland by intensification is by far the biggest threat to biodiversity, says Bamford, dwarfing the impacts of invasive species, climate change and pollution. The farming and food sector is also responsible for over 30 per cent of anthropogenic greenhouse gas emissions. But we have to eat.

Almost everyone agrees that the way we meet that demand has to change for the sake of nature and humanity, but there is a fractious debate about how, encapsulated by two opposing visions. One, known as land sparing, involves extreme yield increases on smaller areas of land, freeing up space for nature. The other, land sharing, advocates nature-friendly farming on larger plots, with biodiversity as part of the system.

Last month, I wrote approvingly about a type of dairy farming called “cow with calf” as practised by The Ethical Dairy in Scotland. This leans towards land sharing, and can be more ethical than and almost as productive as standard farming. But Bamford says large-scale land sharing ultimately lowers yields and risks backfiring by swallowing ever more land. I still approve of The Ethical Dairy, but it seems it won’t scale up.

I experienced this tension for myself during a recent visit to Eryri, the national park in north Wales formerly known as Snowdonia. The trip was sponsored by BMW, which is funding an ecological restoration project in Eryri that aims to clean up Llyn Tegid (Lake Bala in English). Its waters are badly polluted with agricultural phosphates.

> **“There is a perception among farmers that rewilding means generations of hard toil and cost will go to rack and ruin”**

We visited a farm run by Cemlyn Thomas that overlooks the lake. He is a fifth-generation dairy, pig and sheep farmer who, like many of his peers, is keen to make the farm more nature-friendly. He is participating in the restoration project, creating a series of ponds to intercept runoff and stop it going straight into the river Dee and on to Llyn Tegid, as well as reviving a traditional Welsh hedgelaying style that is good for carbon sequestration and habitat diversity and connectivity.

While talking to Thomas, I made a faux pas by uttering a taboo word: rewilding. “We don’t use ‘rewilding’,” says Rhys Owen at Eryri National Park, who is working with (and paying grants to) farmers who contribute to the project. “We say ‘de-intensifying’. It’s very emotive. If you say rewilding, they bring the shotgun out.” I asked why. “People are intimidated by it. It’s the perception that generations of hard toil and cost will go to rack and ruin. But the concept of more biodiversity, that’s not the issue.”

Thomas is also not keen on the word “de-intensifying”, but that is what he is doing, gradually destocking the farm and making changes to how he manages the land to give nature more space.

Getting farmers like him on board is crucial. They have to make a living, which is a challenge, and are generally conservative in their outlook. “You bring in rewilding and they just switch off,” says Owen’s colleague Dion Roberts.

Thomas is a reluctant convert, but says he was motivated in part by summers getting earlier, drier and longer, affecting his sheep farming. He says many of his peers are coming round to the same point of view.

A few weeks later, I attended a Royal Society meeting dedicated to continuing the work of conservation biologist Georgina Mace, where Bamford laid out the cases for land sharing and land sparing. He came down firmly in favour of the latter as the only feasible way to feed 10 billion people and leave enough room for nature. “Wildlife-friendly farming methods that lower yields risk causing damage to most wild species,” he said. But he stressed the need to let farmers take the lead. “Ask the farmers what they want,” he said.

The future of wildlife and humanity depends on which path they choose. As Charles Godfray, director of the Oxford Martin School, has said: “If we fail on food, we fail on everything.” Just don’t mention the R word. ▮

Graham’s week

What I’m reading
Titanium Noir *by Nick Harkaway.*

What I’m watching
Yellowjackets *on Paramount Plus, a dark* Lord of the Flies-*esque drama.*

What I’m working on
A daunting trip to the desert of Saudi Arabia.

This column appears monthly. Up next week: Annalee Newitz

30 Years of Serious Fun!

AQUILA is celebrating a very special birthday this month; this much-loved educational magazine is a best friend to curious and creative children all around the world.

AQUILA Editor, Freya Hardy reflects on why the magazine is so special to her 8 – 14-year-old readers and families:

Unbelievably, AQUILA Children's Magazine is 30 years old this month! Over the years we've printed over 350 issues and covered every topic, from puppets to Pompeii.

We've made carrot ice cream, completed the coin drop challenge and produced a ton of papier-mâché. **We've sent rockets into space (OK, just into next door's garden)**. We've dived into the world of Jacques Cousteau, investigated quantum computers, interviewed volcanologists and folks who design houses on the Moon. But we're not done YET!

AQUILA's most important people don't actually work at AQUILA HQ, because the most important people, the real VIPs, are AQUILA readers! There are thousands of them, in over 90 countries. Some live on the other side of the world, or deep in the countryside, with dogs, rabbits and chickens for company. **Some go to school, others do not**. Some do gymnastics, or raise money for wildlife charities. Some are scientists, mathematicians or engineers. **Some write plays, or like drawing manga**. Some send us envelopes full of sequins in the post (no letter, just the sparkles!).

Some AQUILA readers are 8 years old, and some are eighty, but they all have things in common. They are all curious, compassionate, creative, sometimes contrary, courageous and **FULL TO THE BRIM with BIG ideas.** We would love you to share the AQUILA universe with us too, and here's to another 30 years!

Freya Hardy

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Editor of the Year
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The Summer Double Issue

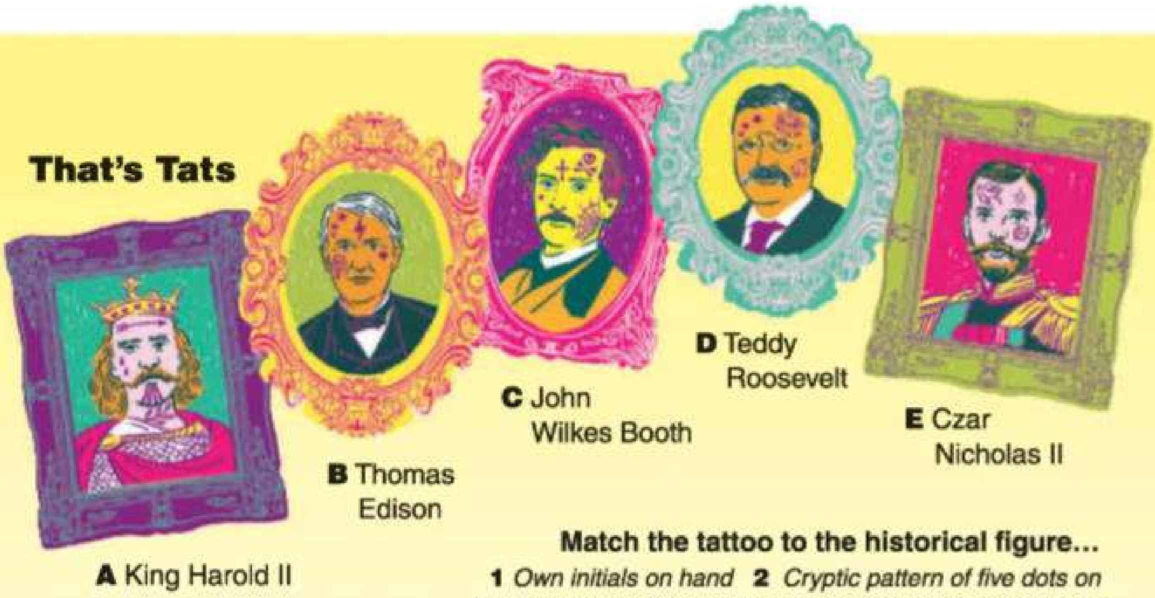
This topic is all about Festivals & Folklore.
Features include:
AQUILA investigates the world's **weirdest festivals**; we learn all about **glow-in-the-dark animals** – could humans be bioluminescent? Make a **Green Man festival crown**; cook a **campfire calzone**; discover why **drumming is so good for you**; be a brilliant detective by solving a **werewolf crime** (ideally before the moon rises!); read about **rock and roll myths and legends**. PLUS: take a visit to the Edinburgh Festival Fringe with **Taskmaster's Little Alex Horne**!

Try these out on the kids…

Jumping Joyce

Joyce lives in 1922 and has invented swanky shoes that let her jump into the future. To begin with, she can jump 5 years ahead, then her shoes buzz with enough energy to take her 10 years ahead for the next jump, then she can go 15 years ahead, then 20 years ahead, then 25 years ahead, and so on. If she wants to get to 2062, how many times will she have to jump?

That's Tats



Match the tattoo to the historical figure…
1 *Own initials on hand* **2** *Cryptic pattern of five dots on forearm* **3** *Dragon on right arm* **4** *Accidental gunpowder tattoos* **5** *'Edith and England' over his heart*

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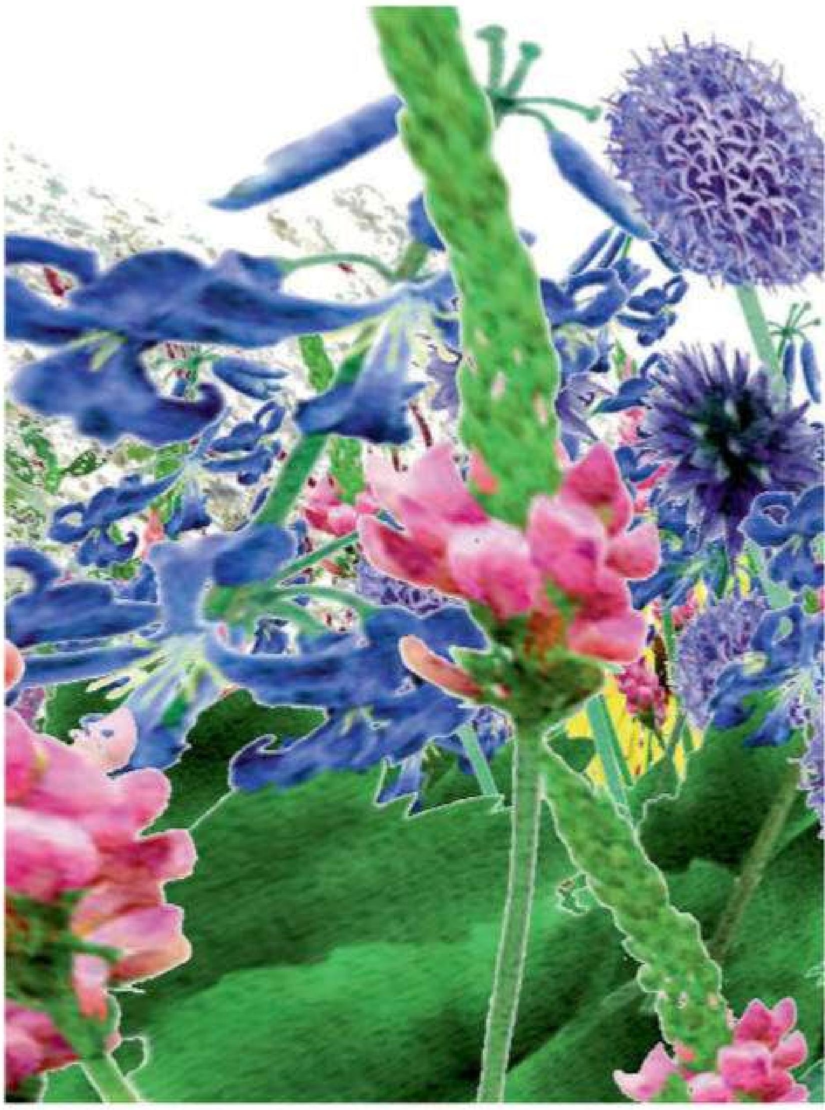
FRANK SPERLING



Blooming great

THESE images document the beginnings of a spectacular and very special type of garden on the grounds of the Natural History Museum Berlin – and one that has come about by a far from typical means.

Artist Alexandra Daisy Ginsberg (pictured left column, centre) worked with a range of experts to develop Pollinator Pathmaker, a garden-planning AI algorithm that is specifically designed to safeguard one of the world's most important types of organism: insect pollinators.

With estimates that around three-quarters of flying insects have disappeared in some areas in the past 30 years, Ginsberg hopes to help slow their decline by using the algorithm to generate garden plans that maximise the number of different pollinators through carefully chosen plant species and arrangements.

The Natural History Museum Berlin's garden, which was commissioned by non-profit group LAS Art Foundation, functions as both a living artwork and a spur to action for the public to plant their own pollinator-friendly gardens using the algorithm's designs. When everything is completed and in bloom, the pollinator site in Berlin will cover 722 square metres and contain more than 7000 plants. It will remain in place until November 2026.

The column of smaller images, taken earlier this year, shows some of the installation process, while the two larger images of flowers are digital renderings of the garden, generated by AI to give an idea of what it will look like once it is finished. They are based on Ginsberg's own paintings.

Gege Li

Editor's pick

At last, a politician who makes hard decisions

17 June, p 21

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I would like to thank you for your decision to give space to Mayor of London Sadiq Khan and the London Ultra Low Emission Zone. Though everyone claims to be in favour of ending harmful emissions, when it comes to the point of actually doing something, enthusiasm rapidly fades and self-interest takes over. Khan is facing increasingly vicious opposition to his objectives and what he is attempting needs great courage. It is heartening and greatly encouraging that *New Scientist* has given him this support.

Putting synaesthesia to practical use

10 June, p 40

From Kathryn Bell, London, UK

Your article about synaesthesia didn't really get into everyday uses for it. I have one: all those PINs and passwords we are expected to remember without writing them down. I write the names of the colours associated with the letters and numbers. It works perfectly for me and is a code that would be hard to break. Also missing from the article are other printed or written marks like brackets and punctuation marks. These are all colourless to me, but perhaps not to everyone. By the way, A is definitely not red and K is dark navy blue, nobody's favourite.

AI could relieve us of so much pointless work

Letters, 20 May

From Dan Plant, Solihull, West Midlands, UK

In response to the idea that artificial intelligence may take our jobs, leaving people unable to earn money by working, surely this is the only purpose of AI? The fact that our society is based on the principal that people work for money to buy things and pay taxes is, in my opinion, the real tragedy of the 19th, 20th and early 21st centuries.

Bearing in mind most people's jobs basically entail causing environmental destruction rather than doing something genuinely useful – make-work if you will – and most of the things people buy are superfluous rubbish, reforming society around a new paradigm where people have all they need (not necessarily all they want) and spend their time doing meaningful work, but only if they want to, can only be a good thing.

We certainly have the capability to enact it, if not the will.

Benign machine leader might be our only hope

Letters, 10 June

From Bruce Denness, Niton, Isle of Wight, UK

Stephen Etzel is right that "AI will never be able to successfully handle the inherently irrational aspects of human politics" – but only as currently practised in democracies, dictatorships or other forms of government.

However, none of these systems is perfect, nor do they necessarily meet the needs and wishes of the majority. For instance, many nations agree that global warming is happening and that emissions need to be reduced. Yet those same nations simultaneously strive for largely fossil fuel-propelled economic growth.

It seems very unlikely that this can be resolved other than by a properly informed benign dictator. An AI could act as that dictator. Of course, a mechanism would be needed to stop it being turned off when taking unpopular (but necessary) decisions.

Net-zero plans need to front-load their action

10 June, p 32

From Jonathan Wallace, Newcastle upon Tyne, UK

Passing 1.5°C of warming will be politically significant, but, as you indicate, it isn't a magic threshold below which everything is fine and beyond which we are doomed.

I do worry, though, about the lack of urgency in the UK government strategy for reaching net zero by 2050, which is rear-loaded, depending heavily on future technological advances to create a carbon-free system.

Even if these advances occur as hoped, during the time it takes for this to happen, we will keep on pushing up atmospheric carbon levels and contributing to more warming. We need governments of the UK and other big economies to implement policies that can have an immediate impact, such as improved home insulation and facilitating low-carbon travel.

From Gautam Menon, Walsall, West Midlands, UK

I worry that passing the 1.5°C threshold will be bad news for an ageing population, with high temperatures and humidity leading to an increased risk of heat strokes and cardiovascular and renal side effects, with a significant chance of death.

So wonderful to see maths brought to life

10 June, p 44

From Colin Wright, Wirral, UK

I have just read your article on the maths of efficient packing. I work in the maritime industry, and it is great to see "maths in real life" like this that connects the subject with people's own experiences.

We use exactly this kind of maths when we look at packing containers on ships, thinking about where they have to go to ensure they are easy to unload at the right time. It is also relevant to how we pack things into the containers themselves.

More of this, please. If people can see maths is relevant, but with deeper and wider implications, it can only be a good thing.

Are we really just alien biocomputers?

10 June, p 36

From Gary Golding, Brisbane, Australia

The article on the power of biological computers as self-replicating, low-energy systems, capable of computation and problem solving, brought to mind von Neumann probes.

These are theoretically devised by an extraterrestrial civilisation to colonise the universe with self-replicating machines, usually thought of as being mechanical, not biological, and the most likely sign of advanced aliens.

However, the Fermi paradox raises the question of why, if this is so, we haven't found any such probes. This paradox may now have been solved. What better way to colonise the universe than by seeding planets with biological machines. Perhaps we are the von Neumann probes.

Thanks to cartoonist Tom for his great ideas

3 June, p 55

From Alastair Cardno, Bradford, West Yorkshire, UK

I loved Tom Gauld's depiction of two scientists who discover they are in a cartoon – a great idea, brilliantly drawn. Thanks to Tom for this and his many other tremendous creations.

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

For the record

▮ The universe is 13.8 billion years old (17 June, p 29).

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- Optimising Sleep: Unravelling the neuroscience and enhancing sleep habits
- Your immune system: Can it be "boosted"? If not, why not?
- How to be happy: All you need is stoicism?

Scan me to book

Two and two make five

An intriguing new book asks deceptively simple questions about mathematics that hint at serious complexities beneath, says **Anil Ananthaswamy**

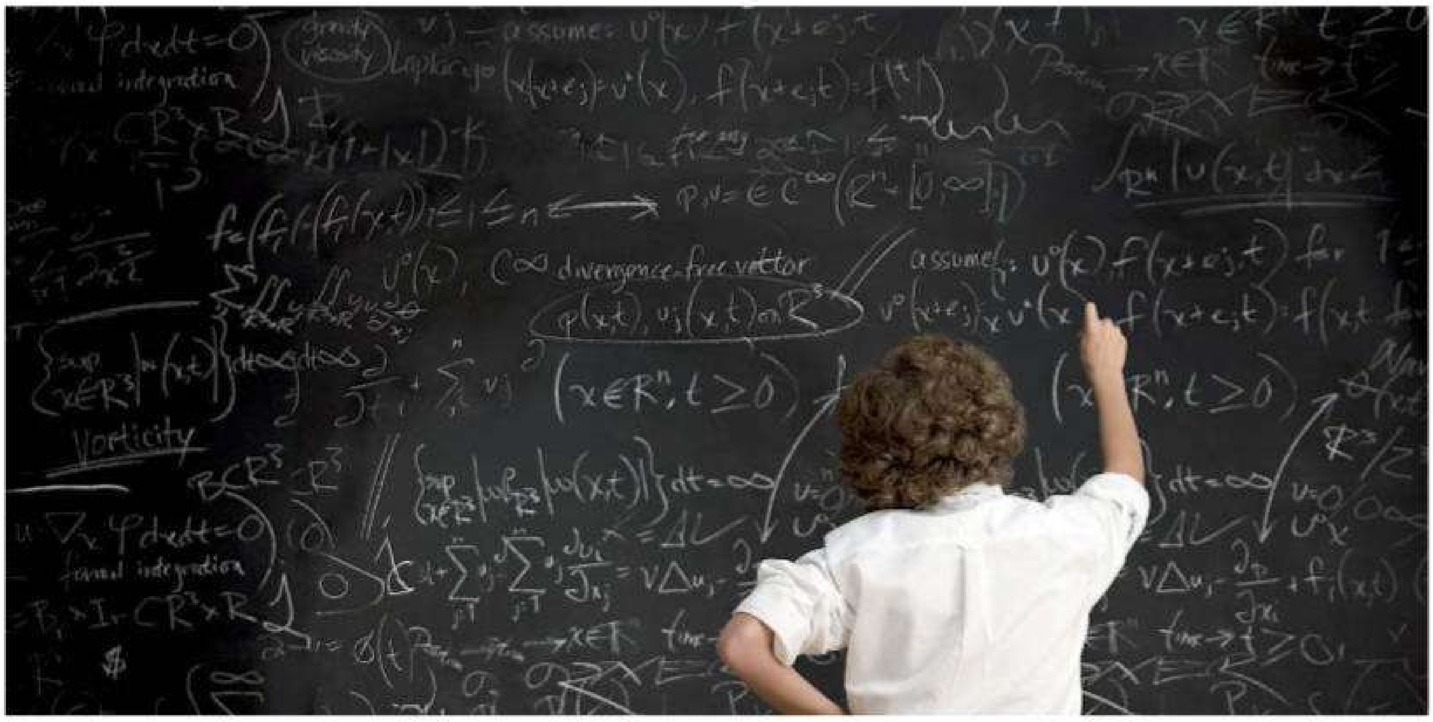


IMAGE SOURCE/ALAMY

Book
Is Maths Real?
Eugenia Cheng
Profile Books

SOME have likened the process of doing abstract mathematics to hacking your way out of some dense forest. Maryam Mirzakhani, the late mathematician and the first of only two women to win a Fields medal, once talked about feeling "lost in a jungle" and of gaining mathematical insights while trying out new tricks to extricate herself.

In mathematician Eugenia Cheng's new book, *Is Maths Real? How simple questions lead us to mathematics' deepest truths*, she uses a similar metaphor to give a glimpse into the mathematician's mind. Each chapter starts with a seemingly innocent question – one that most adults wouldn't dare ask for fear of looking stupid – and then shows how answering such questions seriously is "a slow process of gradually probing and pulling back the undergrowth".

The questions are very basic and the answers seem obvious, except that they aren't. For example: why does 1 + 1 = 2? Why does -(-1) = 1? And why isn't 1 a prime number? OK, maybe that last one isn't so simple, but that's the idea.

Cheng shows us that what look like trivial questions may not be so simple on closer inspection. For example, does 1 + 1 equal 2 in all cases? Understanding when it does and when it doesn't leads to a richer understanding of our underlying assumptions about numbers and their world.

Mathematics, writes Cheng, isn't about getting the right answers to questions, but about knowing how to reason using a framework of logic (if 1 + 1 = 2, then why – or why not?). As she explains: "The solidity of maths comes from not wanting to trust things, but wanting to jump and swing and know that our framework will hold up."

Cheng celebrates the dizziness and disorientation engendered by childlike questions, arguing that these feelings are suggestive of the right kind of bafflement, and pushing yourself to overcome them is crucial to the process.

> **"Mathematics isn't about right answers, but about how to reason using a framework of logic"**

She also succeeds in making the reader feel that not understanding something in mathematics isn't the same as being bad at it; rather, it is a clue that you are onto something deeper, the pursuit of which could reap rewards.

The book is infused with personal ruminations that lighten the load and keep the tone conversational. For example, when Cheng describes -1 as something that cancels out 1, just as antimatter obliterates matter, she writes: "When I was little I thought that pepper was the anti-matter for salt, that is, I thought that if you added too much salt to something you could add some pepper to cancel it out."

She uses real-world examples to help the reader understand mathematical concepts. Take the commutativity of addition, which says that 2 + 4 = 4 + 2, or that the order of addition doesn't matter. But are there situations that are non-commutative, where this isn't the case – and what does non-commutativity mean? Cheng offers a culinary example: to make mayonnaise, start with egg yolks and add olive oil slowly; the other way around doesn't work. "It doesn't commute," she writes.

Cheng wears her heart and politics on her sleeve, segueing seamlessly, and occasionally not so seamlessly, from mathematics to social concerns. Take the issue of why the square root of 2 requires thinking beyond whole numbers and fractions. "The alternative is to allow some new types of number into your life," she writes (the new type here being the irrational numbers).

Not understanding a mathematical problem is the first step to solving it

She uses this opening to call out people who "steadfastly refuse to accept new ways of being as valid (such as same-sex marriage, or non-binary gender, or women mathematicians)". That is "not how mathematics operates," she writes.

To the central question of her book – whether mathematics is real – Cheng's answer sidesteps the philosophical conundrum about whether it is invented or discovered. Very pragmatically, she writes: "The concepts in abstract maths might not be part of the concrete world, but the ideas are as real as any other ideas, and... the insights we get into the real world are very real."

Nicely parried, while providing fodder for those who want to chew on this some more. ▮

Anil Ananthaswamy is the author of the upcoming book *Why Machines Learn: The elegant math behind modern AI*

Our wasteful ways

The human cost of the waste we create daily is vividly captured in an eye-opening book, finds **Chris Stokel-Walker**

Book
Wasteland
Oliver Franklin-Wallis
Simon & Schuster

FROM sewers overflowing with human excrement to the crisis created by the fast-fashion industry, waste is everywhere. This makes *Wasteland: The dirty truth about what we throw away, where it goes, and why it matters* by Oliver Franklin-Wallis all the more pressing at present.

Franklin-Wallis specialises in long, narrative tales in his day job as features editor of the UK magazine *GQ*. In *Wasteland*, he tackles all elements of the effects of waste, from cities in India and Ghana to the banks of the river Thames in London. His eye for detail, honed over years of non-fiction writing, turns the abstract into the immediate – and the alarming.

The solid waste, or garbage, industry contributes 5 per cent to global greenhouse emissions, he writes, more than shipping or aviation. A third of what we throw away is less than 12 months old. "The modern economy is built on trash," writes Franklin-Wallis.

Women's spines are harmed by carrying bundles of clothing to Ghana's Kantamanto Market

ANDREW CABALLERO-REYNOLDS/BLOOMBERG VIA GETTY IMAGES

Many people try to minimise their impact. The author writes of washing yogurt containers and tearing the plastic windows off cardboard sandwich boxes so they can be recycled. Yet it is often all for naught because, as he explains, much of the waste produced in high-income countries, including recycling, ends up in landfill, probably in another country.

Part of what makes *Wasteland* so powerful is that it doesn't chide, unlike some books about the environment. Nor is it a shouty manifesto. Its strongest parts are when Franklin-Wallis walks with those contributing to, or affected by, the failures, injustices and complexities of dealing with waste.

It is through these vignettes that we understand the real impact of, say, fast fashion. A lot of unwanted charity shop clothing is shipped to Africa, Ghana in particular. We meet the Ghanaian municipal waste official who answers questions despite clearly fearing the author is yet another journalist out for quick quotes about the Western predilection for seasonal wardrobe changes, while doing nothing to help change those habits.

Then there is the tearful head of a local charitable foundation, who explains that the spines of women, and the cartilage in their necks, begin to deteriorate within just two months of starting to carry bundles of clothes weighing 55 kilograms on their heads to stalls in Ghana's Kantamanto Market.

Amazing skills are developed in waste industries, too. Take the waste-pickers atop the mountain of rubbish at Ghazipur landfill site in New Delhi, India. They can quickly tell into which category (of 87 at the site) any one item belongs. That is out of a staggering 92,500 tonnes of fresh garbage added daily.

The book doesn't simply cover the stuff we throw in our bins. Chapters on sewerage systems with grand historical sweeps contrast with pointed, first-person visits to new projects designed to alleviate the burden on our water systems.

There is also a section on the least bad way of disposing of nuclear waste from the Sellafield plant in the UK while waiting for the government to fund a more permanent solution – in a building called the Thermal Oxide Reprocessing Plant, or Thorp.

This example might leave things all too visible, but discarding stuff and then forgetting about it is generally easy in the West. Between 1960 and 2010, the amount the average person in the US threw away tripled. Clearly the attitude of those in high-income nations is "out of sight, out of mind".

But Franklin-Wallis ensures we are unable to look away from the impact of the endless production of waste – particularly on people. *Wasteland* isn't a comfortable read, but it is an important one. ▮

Chris Stokel-Walker is a writer based in Newcastle upon Tyne, UK

New Scientist *recommends*

Alexandra Thompson
Assistant news editor
London

This week, I have been enjoying two biologists kicking around big issues on the ***Armchair Expert*** podcast. Lee Hood and Nathan Price roam far and wide, tackling the impact of artificial intelligence on medicine and the future of personalised healthcare. But I was most intrigued by Price's idea that a build-up of amyloid protein in the brain might be a consequence of Alzheimer's disease, not its cause.

MICHAEL AVEDON

I was also lucky to see James Norton in ***A Little Life***, a hugely impressive play at the Harold Pinter Theatre in London that is based on the book of the same name by Hanya Yanagihara. With violence, sexual abuse and self-harm, it isn't for the faint-hearted, but it was remarkably moving.

En route to work, I am reading ***The Plot*** by Jean Hanff Korelitz (pictured), which centres on a novelist who receives threatening messages from a stranger who knows a secret he is desperate to hide. I saw the twist coming, but it is a good yarn.

The games column

Close calls

The much-delayed *Star Trek: Resurgence* has some great individual moments and *Planet of Lana* looks gorgeous, but technical issues in both left me wishing I was watching TV, says **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

Game

Star Trek: Resurgence

Dramatic Labs

PC, PlayStation 4 and 5, Xbox One and Series X/S

Planet of Lana

Wishfully Studios

Xbox One and Series X/S, PC

Jacob also recommends...

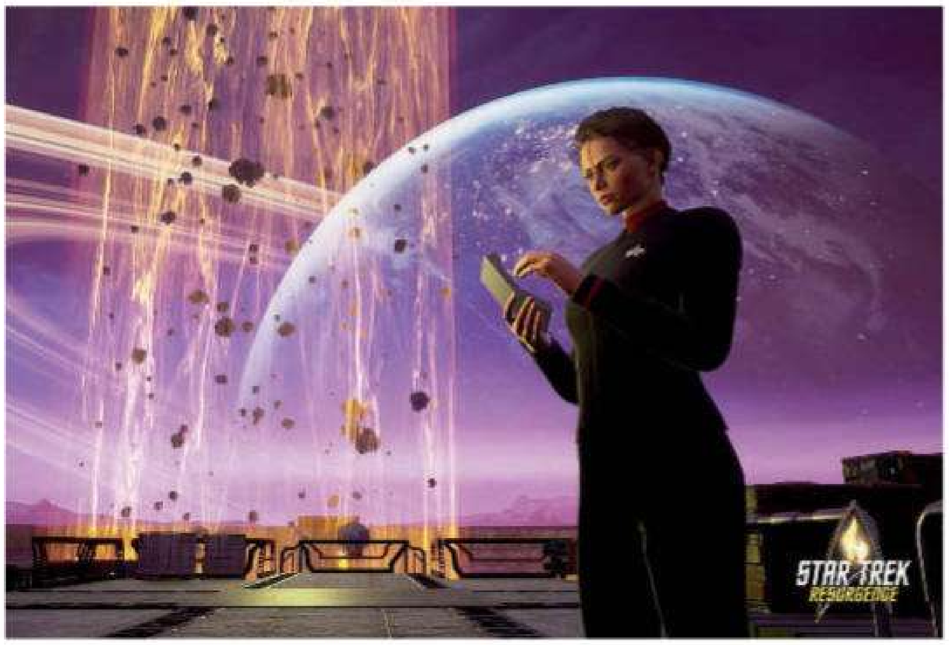
Game

Limbo

Playdead

PC, PlayStation 3, 4 and Vita, Xbox 360 and One, Nintendo Switch, iOS, Android

One of the best puzzle-platformers out there, telling a creepy story with a fantastic art style. Planet of Lana *cribs heavily from its ideas*



DRAMATIC LABS

First officer Jara Rydek is one of two characters you play in *Resurgence*

NORMALLY in this column I try to focus on games that I have really enjoyed – after all, it is more fun to write and read about things that are fun! Unfortunately, the games I have played this month just haven't quite clicked for me, so I thought I would explain why.

First up is *Star Trek: Resurgence*, a game I actually flagged as one to look forward to in 2022, but has only just been released due to production delays. It is a bit baffling, then, that the final game is so unpolished, marring what could otherwise be a great experience.

The *Star Trek* fans among you will know that the franchise is having its best period since the 1990s, with numerous TV shows bringing back old favourites (Spock, Picard) and introducing new ones. Saru, played by the amazing Doug Jones under a heap of prosthetics in *Star Trek: Discovery*, is up there with the greats, in my book.

Resurgence looked like it would follow the same formula, drawing deep from *Star Trek: The Next Generation* nostalgia in terms of style and tone – even down to chapter titles in the same font as the TV show – while giving us a new ship and crew to get to know. The good news is that it absolutely nails this. The bad news is that the game is a boring mess.

In *Resurgence*, you play as two characters on board the USS Resolute: the new first officer, Jara Rydek, and Carter Diaz, a low-ranking engineer. Flipping between the two is a great way of showing the consequences of command. When I was playing as Rydek, for example, I made the decision to follow orders and blow away docking clamps from the ship, even though this would put Diaz, who was conducting a spacewalk on the hull, in danger.

> **"Flipping between two characters is a great way of showing the consequences of command"**

The game is full of good moments like this – the first time Rydek stepped onto the bridge of the Resolute was definitely a thrill – but they are sandwiched between long periods of tedium. It felt like half the game was spent slowly manoeuvring the characters' hands to press a switch or pull a lever, bulking out gameplay in a way that made me wish I was just watching TV.

Technical issues also ruined my immersion in the story, with characters repeating their lines and the camera being in the wrong place. As such, it is hard to recommend the game to any but the most dedicated fans.

The other game I played this month was *Planet of Lana*, in which a peaceful sci-fi world is disturbed by a robotic invasion. The game is absolutely gorgeous, with echoes of Studio Ghibli, but again the moment-to-moment gameplay left me cold.

You play as a young girl, Lana, and after a short introductory sequence find yourself fleeing from said robots, which have more than a passing resemblance to the Martians from *The War of the Worlds*. You are soon joined by a cute animal companion and the two of you have to traverse the world without being captured. This mostly plays out as shifting boxes around so that you can reach high ledges or block an attack by a robot.

That is a fairly compressed description of the experience, but having played many similar puzzle-platformers in the past, I started to feel as if, hidden behind the beautiful art, I could actually see the bland cubes I was manipulating just as I had in so many other games previously.

Clunky controls and easily mistimed jumps eventually led me to put down the game in frustration, again wishing that I could just sit back and watch an artfully produced movie version, without the game getting in the way. ▮

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FUTURES FIELDS

	FRIDAY 21 JULY	SATURDAY 22 JULY	SUNDAY 23 JULY
MISSION CONTROL	XAVIER DE KESTELIER · MIHO JANVIER SHEENA CRUICKSHANK · DAVID NUTT PHILIPPA BROWNING · ROWAN SMITH MATTHEW COBB · ARIS KARASTERGIOU THE DARK ROOM · KNIGHTMARE LIVE MATT WINNING: HOT MESS KIDS CINEMA with LEEDS YOUNG FILM FESTIVAL: WALL-E PLUS SELECTED SHORT FILMS	MIKE BERNERS-LEE · MONICA GRADY TAMSIN EDWARDS · MAGGIE ADERIN POCOCK KAREN OLSSON · BRITISH ANTARCTIC SURVEY BRETT MORGEN presents MOONAGE DAYDREAM NISH KUMAR · JOHN ROBERTSON · TIERNAN DOUIEB DAN TIERNAN · KEITH FARNAN KIDS CINEMA with LEEDS YOUNG FILM FESTIVAL: MUPPETS FROM SPACE PLUS SELECTED SHORT FILMS	LIBBY JACKSON · TIM O'BRIEN · REBECCA BOWLER CHRIS LINTOTT · BRITISH ANTARCTIC SURVEY · JIM WILD ADAM BUXTON'S BUG: BOWIE SPECIAL THE DARK ROOM CREATIVE MANCHESTER present DAVID OLUSOGA with GARY YOUNGE JEFFREY BOAKYE with ELLAH WAKATAMA KIDS CINEMA with LEEDS YOUNG FILM FESTIVAL: TBC PLUS SELECTED SHORT FILMS
BIG BANG STAGE	POP UP PUPPET CINEMA OUR KIDS SOCIAL KIDS CINEMA WITH LEEDS YOUNG FILM FESTIVAL	POP UP PUPPET CINEMA · THE DARK ROOM: KIDS CHESTER ZOO: DR SUE AND THE FROZEN ZOO VOLCANOES: WHAT MAKES THEM GO BANG? · SPECTACULAR SCIENCE WITH EXPLORER DOME SCIENCE MADE SIMPLE: THE XX FACTOR	SPECTACULAR SCIENCE with EXPLORER DOME WIGGLY WORMS by THE STORY STEM VOLCANOES: WHAT MAKES THEM GO BANG? POP UP PUPPET CINEMA · plus SCIENCE MADE SIMPLE PRESENTS THE SCIENCE OF SPORT / THE XX FACTOR

MUSIC FIELDS

	FRIDAY 21 JULY	SATURDAY 22 JULY	SUNDAY 23 JULY
LOVELL STAGE	**ROISIN MURPHY** DJANGO DJANGO · NUBYA GARCIA CMAT · GINA BIRCH · MISS GRIT TC & THE GROOVE FAMILY plus SCIENCE WITH JODRELL BANK	**PAVEMENT** DRY CLEANING · TINARIWEN PICTISH TRAIL · SORRY HENGE · BRAINIAC plus SCIENCE WITH JODRELL BANK	**GRACE JONES** YOUNG FATHERS · GEORGIA TELEMAN · BIG JOANIE · CKTRL SCIENCE WITH JODRELL BANK plus SPECIAL GUEST BC CAMPLIGHT

plus THURSDAY OPENING CONCERT **MAX RICHTER** VOICES AND RECOMPOSED

	FRIDAY 21 JULY	SATURDAY 22 JULY	SUNDAY 23 JULY
ORBIT	**LEFTFIELD** BLACK COUNTRY, NEW ROAD · BEAK> GWENNO · DAVID HOLMES · CREEP SHOW MADMADMAD · ANTONY SZMIEREK PICTURE PARLOUR	**2MANYDJS** DJ SET THE GO! TEAM · EROL ALKAN · ELKKA SNAPPED ANKLES · BELIEF · TVAM FOXTRAP · MARY IN THE JUNKYARD	**MAX COOPER** 3D/AV KOKOROKO · NIHILOXICA · LAVA LA RUE RADIOPHONIC WORKSHOP SKINNY PELEMBE · JESSICA WINTER PLUS THE CLOSING PARTY WITH **ANNIE MAC**
NEBULA	**FUTURE UTOPIA** ONIPA · NIMMO · TOM RASMUSSEN BABA ALI/UNITED FREEDOM COLLECTIVE DELLAXOZ · ATTAWALPA · NOELLE	**DEPTFORD NORTHERN SOUL CLUB** THE BRUDENELL PRESENT ISHMAEL ENSEMBLE DIVORCE · FOLLY GROUP · M(H)AOL · 7EBRA EGYPTIAN BLUE · TREEBOY & ARC · SPIELMAN plus STICKY HEAT	**SCALPING** JASPER TYGNER · ACID KLAUS · MI MYE FREAK SLUG · CALLUM EASTER · HOLODRUM DIEKAIDIE · VACANT WEEKEND · SAMXEMMA
DEEP SPACE DISCO	SOUNDS FROM THE OTHER CITY JOY SOCIAL · BOWIE DISCO DJ FALLBACK	JAGUAR SKILLS presents WEDDING CRASHERS HENGE TAKEOVER · DJ ACID REFLUX BIG FISH LITTLE FISH · BHANGRACISE WE BROKE FREE	THE NEXTMEN · SUPERNATURE LYCRA 80S PARTY · BIG FISH LITTLE FISH DRUM & BOUNCE · GOOD AFTERNOON SHAOLIN MONKEY

STAR FIELDS

	FRIDAY 21 JULY	SATURDAY 22 JULY	SUNDAY 23 JULY
NOTES	THE LISTENING PARTY LIVE with THE GO TEAM SHAUN KEAVENY'S COMMUNITY GARDEN RADIO THE BLUEDOT PODCAST with CHRIS HAWKINS NEW SCIENTIST PODCAST · SING YOURSELF HEALTHY	THE LISTENING PARTY LIVE with PAVEMENT LINTOTT & PRETTY'S UNIVERSE OF MUSIC WHITE RABBIT BOOKS present MIKI BERENYI ADELE STRIPE & LIAS SAOUDI STUART BRAITHWAITE & DAVID KEENAN SING YOURSELF HEALTHY · INDEPENDENT SAGE	60 YEARS OF DOCTOR WHO curated by TOBY HADOKE and DELIA DERBYSHIRE DAY FEATURING ROBIN INCE and more THE LISTENING PARTY LIVE with SPECIAL GUEST revealed soon THE BLUEDOT PODCAST with CHRIS HAWKINS SING YOURSELF HEALTHY
STAR PAVILION		LINA LEVIN PRESTON · FEDERICO DI VRUNO · SHEILA KANANI OUR FRAGILE SPACE PANEL · SIMON GARRINGTON · JAMES GREGAN ALBERT ZIJLSTRA · COLLISION: STORIES FROM CERN	WENDY WILLIAMS · SARAH CROWTHER CHRIS CONSELICE · LAURA WOLZ · JESS WADE

ACROSS THE WEEKEND
OUR FRAGILE SPACE: EXHIBITION BY MAX ALEXANDER
CRAFT PUNKS COSTUME MAKING STATION · BLACKWELLS BOOK STORE
SPACE CARNIVAL PARADE · TELESCOPE VIEWING EXPERIENCE

THE OUTER SPACE

TAAL YATRA BY OPERA NORTH · CELESTIAL SOUND CLOUD BY PIF-PAF · CLOUD CHAMBER BY TYPETHING COLLECTIVE · ORIGINS BY THE KAZIMIER · ORCHESTRA OF OBJECTS
HUMAN JUKEBOX BY DJUKEBOX · JEDI LIGHTSABER TRAINING · DJ SCHOOL · DANCE LIKE A MOTHER · OUR KIDS SOCIAL · STORYTELLING YOGA

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COKE NAVARRO

Rethinking civilisation

The new story of how civilisation emerged upends almost everything we thought we knew, finds **Michael Marshall**

FOR almost all of human existence, our species has been roaming the planet, living in small groups, hunting and gathering, moving to new areas when the climate was favourable, retreating when it turned nasty. For hundreds of thousands of years, our ancestors used fire to cook and warm themselves. They made tools, shelters, clothing and jewellery – although their possessions were limited to what they could carry. They occasionally came across other hominins, like Neanderthals, and sometimes had sex with them. Across vast swathes of time, history played out, unrecorded.

Then, about 10,000 years ago, everything began to change.

In a few places, people started growing crops. They spent more time in the same spot. They built villages and towns. Various unsung geniuses invented writing, money, the wheel and gunpowder. Within just a few thousand years – the blink of an eye in evolutionary time – cities, empires and factories mushroomed all over the world. Today, Earth is surrounded by orbiting satellites and criss-crossed by internet cables. Nothing else like this has ever happened.

Archaeologists and anthropologists have sought to explain why this rapid and extraordinary transformation occurred. Their most prevalent narrative describes a sort of trap: once people started farming, there was no way back from a cascade of increasing social complexity that led inexorably to hierarchy, inequality and environmental destruction. This bleak view of civilisation's rise has long held sway. However, the more societies we look at, the more it falls to pieces. Confronted with inconvenient evidence, we are being forced to retell our own origin story. In doing so, we are also rethinking what a society can be.

Our species, *Homo sapiens,* has existed for about 300,000 years – give or take a few tens of millennia. For almost all that time – including during the tumult of glaciations – we have been hunters and gatherers. So why abandon a lifestyle that worked well for so long? This is the foundational question at the root of human civilisation. "There is no obvious reason for people starting to live in villages and domesticate [crops and animals]," says Laura Dietrich at the Austrian Archaeological Institute in Vienna. "This is one of the biggest disruptions in the history of mankind."

Nevertheless, even discussing the topic can be difficult. Historically, Western thinkers have tended to treat modern industrialised society as inherently better than that of hunter-gatherers, clouding their thinking. "We can't take it for granted that it's always a good thing, or even that it's always a bad thing," says Daniel Hoyer, project manager at Seshat: Global History Databank, which transforms the vast amount of information on past human societies into a form amenable to research into these issues. In addition, much of the terminology on this transition is loaded with unpleasant assumptions about race, gender and empire. The word "civilisation" in particular has obvious undertones, especially when contrasted with "barbarians", "savages" and "primitives".

Despite these difficulties, anthropologists have pieced together a story to explain the massive social upheaval in our recent evolutionary history. The thinking was that people in a few particularly fertile places tried farming because it seemed

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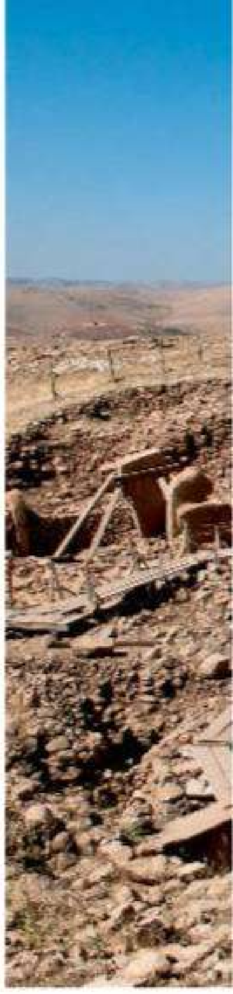
A history of Britain through burials
Alice Roberts will explore how burial archaeology sheds light on ancient societies at New Scientist Live **newscientistlive.com**

like a good idea – then found there was no way back. By producing more food, they triggered population growth, forcing them to grow ever more food. Individuals who could control supplies of grain did so, becoming the first rulers and emperors in what had previously been egalitarian societies. To maintain control, they created or harnessed the apparatus of state, like writing, legislation and armies. In this view, civilisation has pluses and minuses. It brings benefits, like literature, medicine and rock music, but also comes with costs, like inequality, taxes and lethal pandemic diseases that spread to us from livestock. Like Doctor Faustus, our ancestors made a deal with the devil. The story of civilisation is a tragicomedy with some of the power of a great myth.

Now, growing evidence suggests it is a fiction. The first problem is that it misrepresents hunter-gatherer societies, which turn out to be far more variable and complex than we thought. This mistake is epitomised by Göbekli Tepe, located on a hilltop in southern Turkey. Beginning in the mid-1990s, excavations there revealed a series of circular enclosures each containing T-shaped stone pillars several metres high, some with carvings of animals or other symbols. Surrounding these enclosures are rectangular buildings. All this would be unsurprising, except that Göbekli Tepe dates from between 11,500 and 10,000 years ago – before the origin of agriculture. "We don't have domesticated plants or domesticated animals there," says Dietrich. Here is evidence that hunter-gatherers sometimes created monumental architecture, something previously thought to be unique to settled agricultural societies.

We can't know why Göbekli Tepe was built. It seems it wasn't a living space: there is no source of water and no evidence of permanent fireplaces, so few people can have resided there year-round, according to Dietrich. However, the stone pillars, or megaliths, are too large to have been carried by small groups. "The main building evidence can be associated with groups coming from other regions to meet there to make something, with a common idea," she says. That common idea might have been religious, or some more nebulous ritual. The imagery has been interpreted as male: some of the carved animals have penises, whereas there are no obvious female representations. A few human skulls have been found, but their sex is hard to determine. There are also stone troughs that were used to process wild cereal grains into porridge and huge quantities of beer. Some suspect it was a place where groups of men gathered to perform initiation rituals.

"Archaeologists didn't know something like Göbekli Tepe could exist," says Dietrich. However, since its discovery, megaliths of similar ages have been found at nearby sites like Karahan Tepe, as have other forms of monument built by hunter-gatherers, like the huge earthworks at Poverty Point, Louisiana. These are dramatic examples of hunter-gatherers acting in unexpectedly sophisticated ways. There are others.


TEOMANCIMIT (CC BY-SA 3.0)

> "Hunter-gatherer societies turn out to be far more sophisticated than we thought"

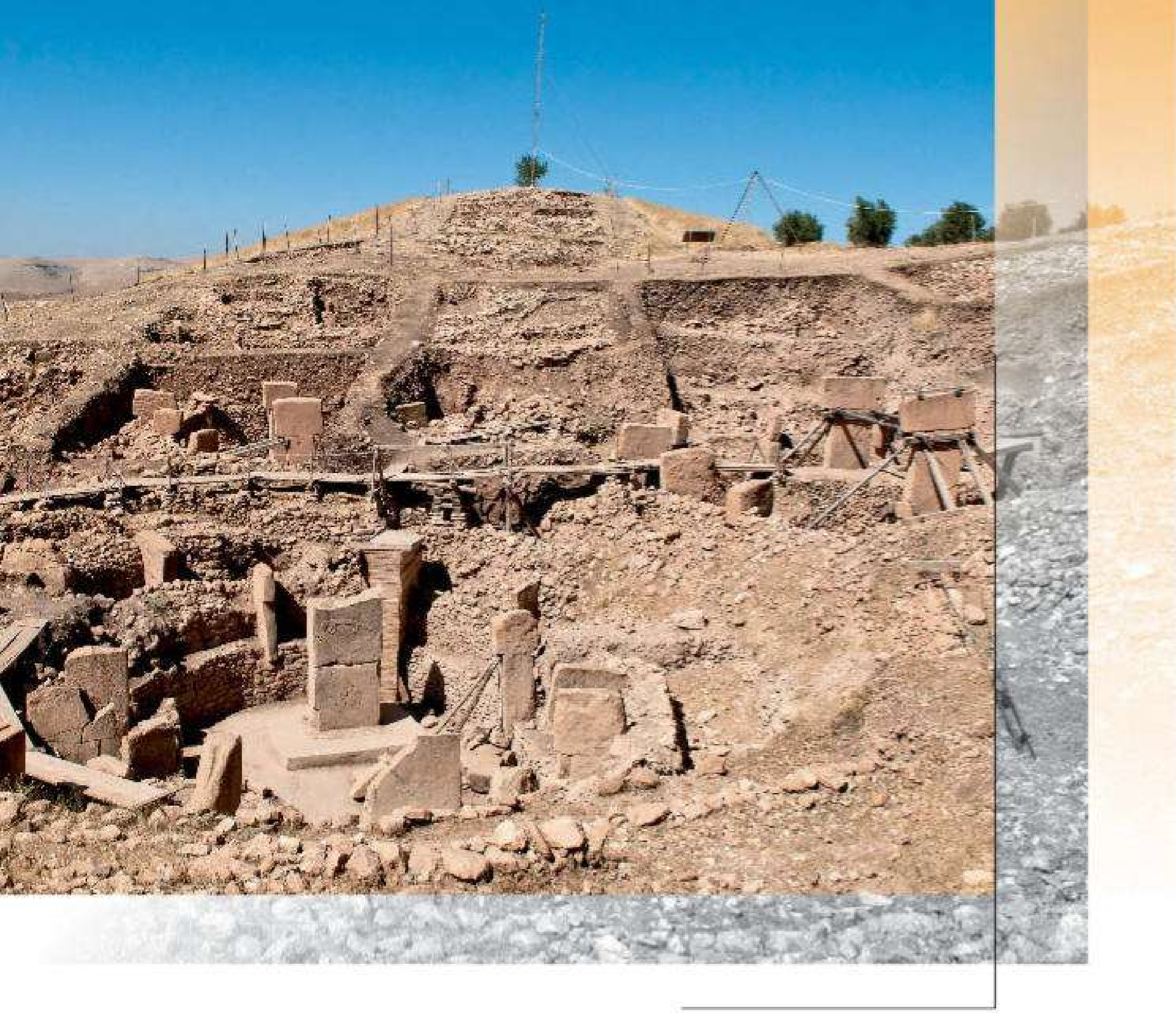
In recent decades, studies of modern hunter-gatherer groups have upended our ideas about their social structures, too. "Typically, people think of hunter-gatherers as living in small, nomadic bands that are fairly egalitarian and cooperative," says Adrian Jaeggi at the University of Zurich, Switzerland. "But actually, there are quite a few examples of what some call 'complex hunter-gatherers'. Those are people who can be fairly sedentary and have a high degree of political stratification. There can be a hereditary ruling class, for example, where you have chieftainship that is inherited. They have slavery and warfare."

It may be that some hunter-gatherer groups behaved in these ways for tens of thousands of years. "We don't have too much direct evidence. But there are some burials of people with ornamentation and stuff that looked like they might have been rulers, that are 20,000, 30,000 years old," says Jaeggi. Much of the evidence has probably rotted away, or been hidden. Göbekli Tepe itself was deliberately buried for reasons unknown.

While many questions remain, one thing is clear. The traditional story – that complex societies began with the development of agriculture – doesn't stack up, at least not all the time. Hunter-gatherers could form large groups, perform rituals and construct

Farming and hunter-gathering aren't mutually exclusive, as the Maasai attest

BRENT STIRTON/GETTY IMAGES REPORTAGE



elaborate monuments. Farming wasn't a prerequisite for this.

The second big source of confusion is why people took up farming at all. It is helpful to imagine what early farms were like, says Amy Bogaard at the University of Oxford. Forget about modern, large-scale, industrial farming, this is more like gardening. "Think of a radically different spatial scale, but also a greater intensity of focus, and the potential enhancement of growing conditions that can happen on that smaller scale." Also, note that the first farmers weren't just farming. "There's still a lot of gathering and hunting and fishing and fowling going on alongside," she says.

Feast or famine?

The obvious reason people might have started farming is that it produced more food, or at least a more predictable supply. However, there is limited evidence for this. In fact, the opposite has been argued. Jared Diamond at the University of California, Los Angeles, famously called farming "the worst mistake in the history of the human race", citing evidence that early farmers were shorter than hunter-gatherers, more prone to malnutrition and disease and had shorter lives. But these are all sweeping generalisations. The evidence we now have suggests that we must weigh up what was happening at the regional level.

Consider Çatalhöyük in Turkey, a community of farmers living in a dense village between 7100 and 5600 BC. "It's kind of the ultimate experimental dataset that runs for 1500 years, and it runs pretty successfully," says Bogaard. "There are some ups and downs in the size of the community, but it has a very diverse cropping system, it has five or six cereals, a similar number of pulses and a lot of foraging." In contrast, farming in Britain got off to a rocky start. By the time agriculture reached it, many key crops had been dropped, leaving only a few cereals. The result was a volatile boom-and-bust cycle in which populations grew for a few centuries, but then shrank and dispersed when crops failed. "It's just not diverse enough," says Bogaard. "There isn't a big enough archive of [crop] species to keep rebounding from those inevitable ups and downs."

These radically different experiences of farming may explain why larger datasets don't show an overall decline in human stature. A study published this year by Jay Stock at Western University in Ontario, Canada, and his colleagues compiled information on 3507 skeletons from Europe, Asia and North Africa, dating from 34,300 years ago to the present. Average body size declined from the start, long before the advent of farming, until about 6000 years ago, when it rose again – possibly because of the development of dairy farming.

Admittedly, it isn't obvious that farming offered nutritional gains. But it also doesn't look like a trap. "There are quite a few examples of groups who adopted and then abandoned agriculture," says David Wengrow at University College London. One is in the North American south-west where, before Europeans arrived, communities were giving up growing maize and beans in favour of foraging. "Sometimes it happened in prehistory too," he adds. "Stonehenge and other Neolithic monuments of the British Isles were built by populations who adopted cereal farming from continental Europe, but then reverted to collecting hazelnuts as their staple plant food."

Perhaps there were sociopolitical reasons for the rise of farming. One suggestion is that an existing tradition of private ownership was necessary. Samuel Bowles at the Santa Fe Institute in New Mexico and Jung-Kyoo Choi at Kyungpook National University in Daegu, South Korea, used a mathematical model to show that farming would have been more advantageous in societies where people were allowed to hold property. That rings true to Jaeggi. "When resources can be monopolised and you can store your food for future use, then it makes sense," he says. There could also be cultural reasons to farm. "People want to stay in a certain place," says Bogaard. "They are attached to that part of the landscape and they're doing whatever is necessary to make that ecologically plausible." Activities like

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Göbekli Tepe (above and below) was created before the advent of farming, undermining the notion that hunter-gatherers didn't build monuments

UCHAR/GETTY IMAGES

NDEDE/SHUTTERSTOCK

SOCIALLY ENTERPRISING

Emerging evidence from the study of human societies past and present reveals a "staggering kaleidoscope of social experimentation", says David Wengrow at University College London. It is tempting to fit societies into neat categories such as hunter-gatherer versus complex, egalitarian versus hierarchical and democratic versus authoritarian. It turns out to be not that simple. What's more, a society can change drastically if its members choose.

One such transition took place on Rapa Nui, also known as Easter Island, in the south-east Pacific. The first settlers established sub-chiefs, each with power over one region of the island and all subordinate to an overall chief. "The chief would have been hereditary," says Jennifer Kahn at the College of William & Mary in Virginia. "It's an ascribed position like a monarchy, where you are born into gaining that title." However, this centralised system proved unstable, so around 1600 the people of Rapa Nui overturned it. In its place they established a birdman cult. Every year, warriors competed by swimming through shark-infested waters to a small islet where they collected a bird's egg and swam back. "The first one that arrives with their egg unbroken becomes chief for the year," says Kahn. "It's an achieved position... that warrior could even be somebody from a low rank."

"Much of the art accords women an independent place, by no means subordinate to men"

Admittedly, shifts in governance usually happen gradually. What is remarkable, though, is how much these power structures vary from one group to another – even when, superficially, they look similar. Take the US and Mongolia, both of which are headed by an elected president. "The US has a very specialised hierarchy, but you go to Mongolia and it's much more level," says Stefani Crabtree at Utah State University. "Yes, there's a president, but they have this steppe ethos that comes from Chinggis [Genghis] Khan of 'everyone can have a say'."

Egalitarianism is generally seen as a characteristic of hunter-gatherer societies, with hierarchies emerging as societies become more complex. This shows that idea to be simplistic: some forms of hierarchy are more egalitarian than others.

Evidence from past societies upends another assumption about hierarchies – that men are always in charge. The majority of complex societies are indeed patriarchal, but patriarchy isn't inevitable. "Actually, some of the earliest societies to adopt farming seem to have accorded a high or at least equal status to women," says Wengrow. He points to Çatalhöyük in Turkey, the remains of one of the oldest examples of densely populated "urban" living supported by agriculture. "There is nothing to suggest a patriarchal system. [Research] suggests men and women lived to similar ages and enjoyed comparable standards of living. And much of the art and symbolism at Çatalhöyük and other Neolithic sites accords women an independent place, by no means subordinate to men."

Beyond patriarchy

Even powerful empires weren't all patriarchies. Between about 200 BC and AD 100, the east Eurasian steppe was controlled by a nomadic empire called the Xiongnu. There is archaeological evidence of Xiongnu women riding horses and doing archery. Furthermore, a study published in April described DNA from 18 Xiongnu people and found that the highest-status graves contained women. One woman was buried in a decorated wooden plank coffin with six horses, Chinese bronze chariot pieces and a bronze pot. The implication is that women held elite political and military roles in the Xiongnu society.

We also need to rethink another defining characteristic of complex societies – urbanisation. We tend to think it means thousands or even millions of people living in a small area, sometimes literally on top of each other in skyscrapers. However, even in today's world, the process of urbanisation is far from homogeneous. A 2020 study examining how large cities changed between 2001 and 2018 found dramatically different growth patterns: some cities expanded their populations far faster than their built-up areas, while rates of urban greening also varied enormously. Furthermore, archaeological evidence reveals that cities can take radically different forms.

One dramatic example is the "distributed cities" that existed in the Amazon rainforest before the arrival of Europeans. Each of these cities may have had a population of millions, but they didn't look anything like New York or Singapore. Instead, a city comprised many villages, each surrounded by a mix of crop fields and managed rainforest where residents tended dozens of types of domesticated plants and animals. Crucially, the villages were connected by a vast network of roads made of compressed earth, spanning hundreds of kilometres. These were cities without a centre.

What all this shows is human ingenuity. The societies we create vary depending on the ecological, social and political environment. For hundreds of thousands of years, all humans were hunter-gatherers, now most live in complex societies. Just as we are revising our ideas of how this transition happened (see main story), we also need to rethink this simple dichotomy. The forms that a human society can take are far more exuberant than most people realise. And there is no reason to stop innovating now. "When we begin to see all the possible pathways that weren't taken," says Wengrow, "it allows us to think more freely and creatively about alternatives in the present."

The people of Easter Island have shown that systems of governance aren't set in stone

LEFT: HAPPYTOBEHOMELESS/GETTY IMAGES; UPPER: EDUARDO SOTERAS/AFP VIA GETTY IMAGES

Moralising religions such as Islam can bond large groups of people together...

ABDEL GHANI BASHIR/AFP VIA GETTY IMAGES

...but may not have driven social complexification

SAJJAD HUSSAIN/AFP VIA GETTY IMAGES

burials, allowing people to remain near to their dead relatives, are evidence of this.

That still leaves the puzzle of why people in places as disparate as Mesopotamia, northern China and South America all pivoted to farming within a few millennia of each other. The answer may lie in climate change. During the period before about 10,000 years ago – the Pleistocene – temperatures fluctuated a lot over decades and centuries. "A nomadic hunting and gathering lifestyle is the best way to make a living when conditions are so unpredictable," says Jaeggi. Since then, during our current Holocene epoch, a more predictable climate has allowed farming to thrive. Nevertheless, humans didn't start farming and building complex societies just in the Holocene – on the contrary, "it has always been happening", says Hoyer. It is just that people couldn't adopt sedentary agricultural living permanently while the climate was unstable.

To summarise, we now know that hunter-gatherer societies were far more variable than we thought, including some that had hierarchies and built monuments. We also know that farming wasn't a trap, nor was it unambiguously good or bad: it depended on where and how it was being done.

The next challenge is to explain why some societies became dramatically more complex – socially stratified with powerful leaders and the rapid invention of writing, money and new technologies. The difficulty here is disentangling the many ways that these societies changed and to figure out what is cause and what is effect. One of the most prominent attempts at this is the Seshat project, named for the Egyptian goddess of writing and knowledge. "We've compiled this huge database of information about the past," says Hoyer. It describes changes in societies at 100-year intervals, using a range of variables to assess complexity. Begun in 2011, Seshat has started to produce some eye-catching findings.

The first major study, published in 2017, asked whether societies tend to develop in similar ways or follow their own, unique paths. The Seshat team looked at 414 societies from the past 10,000 years. For each, there was data for 51 variables, ranging from spatial scale and population density to levels of administrative hierarchy, use of writing and construction of public systems that benefit all, like irrigation networks. It turned out that the process of complexification looked similar in every case. "They are gaining these features all at once and this is true cross-culturally throughout time," says Hoyer.

The spoils of war

Five years later, the Seshat researchers tried to discover what instigates this societal transformation. They listed 17 possibilities, such as agriculture, geographic scale and social hierarchy, and searched the data, reasoning that if one factor tended to be the driver, it would generally precede the others. The analysis suggested that farming did play a role, but the most important factor was warfare. "It's the intensity of military technology, of the threat of other societies, how powerful they are, how much they are able to eradicate you," says Hoyer. The emergence of iron weapons and cavalry in the first millennium BC was particularly crucial. "There's this very strong selective pressure to adopt them or be run over by someone who already has them."

Jaeggi isn't entirely convinced by the finding. "I think their result makes a lot of sense for societies that are already agricultural," he says, because farmed foods can be monopolised and fought over. But he thinks that societies become complex in two stages. In a 2021 study, he and his colleagues examined 186 modern non-industrial societies, creating a "family tree" of how they are related to work out how they have changed over time. This showed the path to a complex society begins with "resource-use intensification" – meaning more agriculture, but also less hunting, more food storage and an increasingly sedentary, urbanised and dense population. Only then could technological and sociopolitical change happen. "What we're adding is kind of an earlier stage," says Jaeggi.

Timothy Kohler at Washington State University is also sceptical that warfare drives the process. In 2020, he and his colleagues analysed the Seshat data for themselves. They found that societies grew in population and geographical scale – but only until they reached a threshold. The initial scaling up often occurred through annexing adjacent polities by force. However, to get beyond the threshold, a society had to develop "information processing" systems like writing. "Conflict is important because it increases the scale," “People have sometimes abandoned complex hierarchical societies”

says Kohler, but warfare isn’t the whole story.

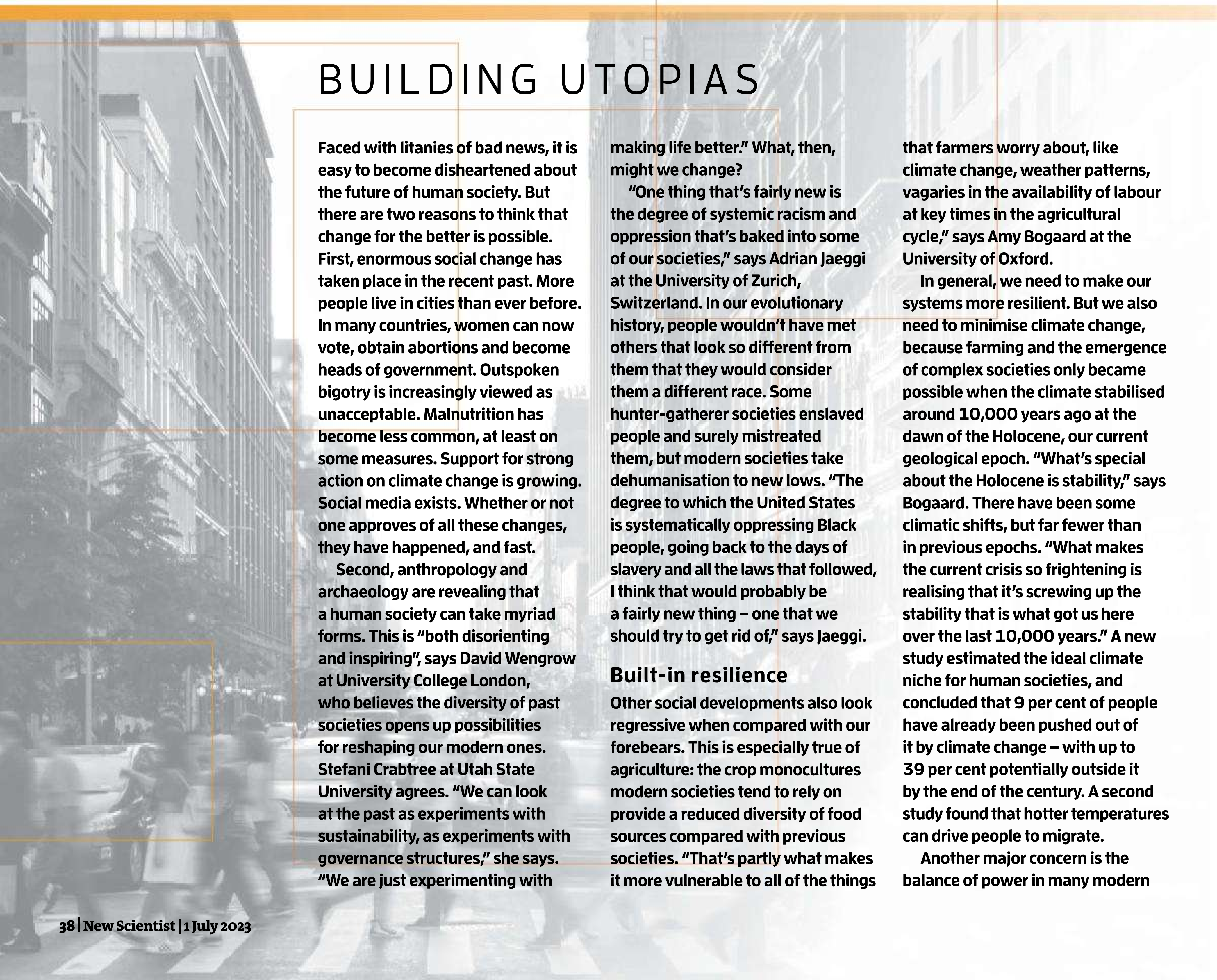
Another key result from the Seshat team has proved even more contentious. Previous research had suggested that religious belief can hold a society together and that the concept of “moralising gods” – ones that take a strong interest in right and wrong – is crucial to the formation of large states. However, in 2019, the Seshat team concluded that belief in moralising gods only emerged after societies were already large, so couldn’t have been the driver. A response paper called this into question: “They had a lot of missing values in their dataset” and each was coded as evidence of absence of moralising gods, says Rachel Spicer at the London School of Economics. The Seshat paper was later retracted. But the team has now redone the analyses and published the same conclusions.

Creative constructions

Nevertheless, some researchers see this episode as symptomatic of a deeper issue with Seshat, arguing that the way the data is coded is loaded with preconceptions. For Wengrow, this is a fatal flaw. For example, he sees the warfare finding as largely an artefact of the method. “If you begin, as this Seshat study does, by defining complexity in terms of technologies of violence, control and extraction, then you are logically bound to conclude that technologies of violence, control and extraction are drivers of complexity,” he says.

What all this undoubtedly shows is that understanding the emergence of civilisation is tricky. Where once we had a one-size-fits-all narrative of cause and effect, in recent years, archaeologists and anthropologists have turned away from this approach. “We don’t believe that societies always evolve in this linear way, where we go from hunter-gatherers to complex societies eventually with a few steps in between,” says Stefani Crabtree at Utah State University.

This has become apparent as we cast our net wider. “A lot of what we knew about world prehistory came from the Near East and



BUILDING UTOPIAS

Faced with litanies of bad news, it is easy to become disheartened about the future of human society. But there are two reasons to think that change for the better is possible. First, enormous social change has taken place in the recent past. More people live in cities than ever before. In many countries, women can now vote, obtain abortions and become heads of government. Outspoken bigotry is increasingly viewed as unacceptable. Malnutrition has become less common, at least on some measures. Support for strong action on climate change is growing. Social media exists. Whether or not one approves of all these changes, they have happened, and fast.

Second, anthropology and archaeology are revealing that a human society can take myriad forms. This is “both disorienting and inspiring”, says David Wengrow at University College London, who believes the diversity of past societies opens up possibilities for reshaping our modern ones. Stefani Crabtree at Utah State University agrees. “We can look at the past as experiments with sustainability, as experiments with governance structures,” she says. “We are just experimenting with making life better.” What, then, might we change?

“One thing that’s fairly new is the degree of systemic racism and oppression that’s baked into some of our societies,” says Adrian Jaeggi at the University of Zurich, Switzerland. In our evolutionary history, people wouldn’t have met others that look so different from them that they would consider them a different race. Some hunter-gatherer societies enslaved people and surely mistreated them, but modern societies take dehumanisation to new lows. “The degree to which the United States is systematically oppressing Black people, going back to the days of slavery and all the laws that followed, I think that would probably be a fairly new thing – one that we should try to get rid of,” says Jaeggi.

Built-in resilience

Other social developments also look regressive when compared with our forebears. This is especially true of agriculture: the crop monocultures modern societies tend to rely on provide a reduced diversity of food sources compared with previous societies. “That’s partly what makes it more vulnerable to all of the things that farmers worry about, like climate change, weather patterns, vagaries in the availability of labour at key times in the agricultural cycle,” says Amy Bogaard at the University of Oxford.

In general, we need to make our systems more resilient. But we also need to minimise climate change, because farming and the emergence of complex societies only became possible when the climate stabilised around 10,000 years ago at the dawn of the Holocene, our current geological epoch. “What’s special about the Holocene is stability,” says Bogaard. There have been some climatic shifts, but far fewer than in previous epochs. “What makes the current crisis so frightening is realising that it’s screwing up the stability that is what got us here over the last 10,000 years.” A new study estimated the ideal climate niche for human societies, and concluded that 9 per cent of people have already been pushed out of it by climate change – with up to 39 per cent potentially outside it by the end of the century. A second study found that hotter temperatures can drive people to migrate.

Another major concern is the balance of power in many modern

In an evolutionary eyeblink, cities such as Tokyo have transformed Earth

JACKYENJOYPHOTOGRAPHY/GETTY IMAGES

Europe," says Jennifer Kahn at the College of William & Mary in Virginia. "Now, we have a lot more archaeological data about what's going on in other areas of the world and we see there's a lot more variability." Take the Polynesian societies of the Society Islands in the Pacific, where she has worked for years. In around 1650, a religious cult emerged restricting the power to wage war to a handful of chiefs, who then subsumed smaller chiefdoms into their domains. In other words, although warfare played its part in producing complex chiefdoms, religion mattered too. "Ideology and ritual power was really important to why things got so hierarchical in the Society Islands," says Kahn.

More information about a variety of societies also reveals that people have sometimes abandoned complex hierarchical societies, just as some groups chose to stop farming. At Mesa Verde in south-west Colorado, Native Americans known as the Ancestral Puebloans built dwellings and palaces on the sides of rocky cliffs – and then stopped using them. Crabtree simulated this history in a computer model. "What we see is people going into a more hierarchical, more complex society, where you have centralised leadership," she says. But this didn't work out due to droughts and social unrest. "So they pretty quickly dismantle that hierarchy."

The take-home message is a far cry from our previous picture of civilisation. "There's not one storyline about how societies get more complex," says Kahn. Or, to put it another way, the plot line is much richer and more ingenious than we thought. Understanding the twists and subtexts doesn't just shed new light on our past, it might even help us create better societies in the future (see "Building utopias", left).

What's more, Wengrow, for one, relishes the exuberant, creative diversity of forms that societies can take (see "Socially enterprising", page 36). In fact, he goes further, suggesting we might want to reconsider the very meaning of social complexity. "We might instead choose to define complexity in terms of kinship systems, ecological resilience and artistic creativity," he says. "In which case, I suspect, the Indigenous islanders of Ambrym [in Vanuatu] would come out somewhere near the top, and European societies would be pretty low down." ∎

Michael Marshall is a writer based in Devon, UK, and author of *The Genesis Quest*

societies. While hierarchies may be inevitable in large-scale, complex societies, for them to succeed, people need to believe in them. "Having this kind of social contract between those in power and those not in power is a very important thing," says Jennifer Kahn at the College of William & Mary in Virginia. That requires flattening hierarchies as much as possible in terms of both political power and wealth. "I think economists pretty much agree that too much [wealth] inequality makes society inefficient," says Jaeggi. "It's good for the 1 per cent, but you reach a point where the super-rich stop investing in society as a whole, so you get fewer public goods like a public school system."

Fairer is better

Wealth inequality is also politically destabilising. In this century, climate change will bring enormous challenges, including destruction of infrastructure and massive migrations. In the past, when faced with environmental challenges, some societies coped and others didn't. "They can weather those challenges pretty well if the levels of wealth inequality are not too high," says Timothy Kohler at Washington State University. "When the levels of wealth inequality are high, it seems more likely that will cause social disruption and violence."

The realisation that human social structure is more flexible than we thought may be inspiring, but it isn't obvious how we can change it. Wengrow offers a rule of thumb for creating a better society. "The first and most important feature would be that it wouldn't be designed by me or by any other one person," he says. "I think a more fair and equal society can only come about when people are given the right to make decisions collectively about what they truly value in life and then are given access to material resources which make it possible to distribute those values as widely as possible."

That is challenging, but there is more. We may also have to expand our concept of what a society is. Noting that the problems we face now are often on a global scale, Kohler argues that unless we think big when it comes to our view of society, we are inviting trouble. "To the extent that we don't consider ourselves one global population and try to help each other out – to the extent we see 'us' in competition with 'everybody else' – the world's going to become a very difficult place to live in."

LEFT: RYAN DEBERARDINIS/ALAMY

Cheat your way to better health

Hate exercise? There may be ways to give your body a boost without breaking a sweat, discovers **David Cox**

I AM lying on a table having my body scanned as part of a much-needed appraisal of my physical condition. Overhead, a machine whirs, using low-level X-rays to compute the precise proportions of my fat, bone and muscle.

The results aren't great. I am carrying 8 kilograms too much body fat for a 33-year-old male, while my upper body clearly hasn't seen the inside of a gym for some time. The scan showed that I should aim to get leaner and stronger, while some recent misadventures on a tennis court provided an acute reminder of how far my aerobic capacity has fallen.

I need to get fitter, that much is clear. But like many people, my job is largely sedentary and I often don't find the time to exercise. Which made me wonder: what if there were ways to hack my fitness so that I get more out of the workouts I actually do – or, even better, get fitter without moving a muscle. I have heard it might be possible to sleep yourself fitter, for instance, or that some sports shoes can help you run faster. There has also been talk of an "exercise pill", and of people who can build more muscle just by thinking about it. I decided to investigate some low-effort ways to get my fitness on track, starting with the most basic exercise hack of all: breathing.

For many years, yoga devotees have advocated nasal breathing, and researchers are now interested in its effect on performance during exercise. The main reason for this is that a substance called nitric oxide (NO) is produced in the nasal cavity and inhaled when breathing through the nose, which might hold benefits for the cardiovascular system because NO widens blood vessels to increase blood flow.

SPENCER WILSON

But while NO has been linked with improved exercise endurance in older, sedentary individuals, the NO boost in these studies came from supplements such as L-arginine, rather than breathing itself. Direct comparisons of oral and nasal breathing suggest that nasal breathing is a more efficient way to breathe in terms of delivering oxygen to the bloodstream. However, it isn't yet clear whether this could make your sprint to catch the bus any easier.

Don't give up on breathing training just yet, however. One technique with a long pedigree is respiratory muscle training, or "weight training for the respiratory muscles", says E. Fiona Bailey at the University of Arizona. Taking inspiration from both high-intensity interval training (HIIT) and resistance exercises for other muscle groups in the body, she has designed experiments where participants take five sets of six breaths into a device called Powerbreathe, which makes them apply more force with their diaphragm in order to open a pressure-dependent valve.

In a trial earlier this year, Bailey and her colleagues found that participants who carried out a six-week programme with this device gained endurance and even saw reductions in their blood pressure. "We're strengthening the diaphragm, which leads to a reduced perception of effort during exercise," says Bailey. "It may also improve the mechanics of breathing during exercise and extend the time for which people can work out." Devices such as Powerbreathe can be bought online, so, in theory, anyone can try out this technique at home. "The main challenge is figuring out how intense to set the resistance level," says Bailey, but she is currently working on this.

This is promising, but I was also intrigued by the fact that when I had previously tried breathing exercises they had helped me sleep better, a known benefit of exercise. Could it work the other way round – might some better-quality shut-eye also improve my fitness?

I sleepily switch on Zoom and Matthew Morrison appears on my screen. A researcher at the Australian Catholic University, he investigates whether improving sleep can boost the performance of elite athletes.

Ironically for me, given that we are doing this interview in the middle of the night, UK time, Morrison explains that a major problem is that most of us are sleep deprived, so simply bringing that sleep deficit back up to baseline might make us stronger and improve the efficiency of our aerobic fitness – for example, how much oxygen we require to run at a given pace. This is because a lot of the body's maintenance work takes place while we sleep, affecting metabolism, the growth and repair of tissues and the function of mitochondria, the tiny structures within cells that create the energy our muscles require during exercise.

Research shows that getting just four hours of sleep a night for five nights can have a negative impact on the amount of energy that mitochondria produce. Restricted sleep also reduces testosterone levels and alters the release of growth hormone, both of which are thought to be important for how the body recovers from and adapts to exercise.

One of the other consequences of

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Putting more vigour into everyday tasks is an easy fitness hack

> **"Surprising low-effort tweaks can improve our strength and stamina"**

repeated lack of sleep is that it seems to make us weaker, says Morrison. This is because it reduces the number of new proteins being added to your muscles. "There's a relationship between muscle atrophy and insufficient sleep," he says. "We've seen that it slows down muscle protein synthesis, both over a single night of disrupted sleep and [over] five consecutive nights as well." Much of this data has come from rodents, but a study of 915 men and women in the Netherlands aged 45 to 65 found a relationship between chronic lack of sleep and lower muscle mass. The take-home message is that a good night's sleep is a crucial part of any fitness regime.

Mind over matter

Another, perhaps unsurprising, aspect of sleep is that a lack of it seems to reduce our motivation to exercise, with insomnia and poorer sleep quality linked to lower levels of physical activity – just one example of the power of the mind on our physical health.

"I think the mind is an overlooked and underutilised factor in determining our fitness," says Alia Crum, who directs the Mind and Body Lab at Stanford University, California. "Our beliefs about exercise can shape not only our motivation to exercise, but also influence the benefits of that exercise."

Crum is a pioneer in this area. Back in 2007, she and her colleague Ellen Langer published a study of female hotel-room attendants. At the start of the study, they all considered themselves inactive and worried about the consequences of that on their health. But once Crum and Langer pointed out that they were, in fact, very active and their daily work activities, from lifting to scrubbing, all counted as exercise, the women reported a decrease in body fat and blood pressure. Nothing in their lives had changed other than their mindset.

Studies have since shown that how we perceive our strength contributes to the extent to which our muscles might waste with disuse. When researchers at Ohio University examined the power of visualisation among a group of adults who agreed to have their wrists immobilised for a week to induce weakness, they found that performing daily mental imagery of strong muscle contractions reduced this loss in strength by 50 per cent.

Earlier this year, Crum's latest study indicated how having a different mindset can maximise the benefits of all the incidental exercise we do each day, such as housework or walking around the shops. It appears that tracking our steps through smartwatches and other wearable technologies can make a difference to how we perceive our fitness. The study showed that people who had previously regarded themselves as inactive, but found that they were actually completing about 7000 steps a day, began to report improved mood, better self-esteem and even a boost in aerobic fitness measurements, even though they weren't exercising any more than usual.

An even more unexpected fitness hack might come from our gut. It seems that having the right populations of gut bacteria makes you more likely to exercise. Last December, Christopher Thaiss at the University of Pennsylvania and his colleagues found that differences in gut bacterial populations appeared to play a much greater role than genetics when it came to running performance in mice. They identified two particular bacteria, *Eubacterium rectale* and *Coprococcus eutactus*, as being especially important. When the mice were given these in supplements, it seemed to enhance their desire to exercise. Further investigation showed that the metabolites of these bacteria stimulate sensory nerves in the gut that can enhance activity in a brain region linked with motivation.

It remains to be seen whether this works as effectively in humans. We still have much to learn about whether altering microbial populations through probiotics, prebiotics or a better diet, can make us any fitter, says Shrushti Shah at the University of Calgary in Canada. "The microbiome has been linked to metabolic, gastrointestinal, cardiovascular and musculoskeletal health, as well as immunity development, all of which contribute to improving physical fitness," she says. "But more research is needed in diverse populations to establish the actions of gut microbiota on the physical performance of an individual."

This could be significant, as many of us struggle to find the motivation to exercise.

For instance, a study of adults in Scotland and England aged 40 to 65 found that only 20 per cent did any vigorous structured exercise, such as playing sport or going to the gym, for more than 15 minutes a month.

Everyday activity bursts

However, this doesn't mean that these people are sitting around doing nothing for the majority of their day. Until recently, it was unclear quite how much incidental activity we are doing and what its impact on our health is. Now though, wearable devices mean we are able to investigate the effects on our health of general pottering around, shopping and cleaning in unprecedented detail through large-scale, long-term studies, such as the UK's Biobank project. The findings are music to the ears of gym-avoiders. Mostly.

We now know any activity that expends energy above the baseline level of sitting quietly is beneficial for our overall health. Although you get the largest positive impact from higher-intensity activities (ones that leave you out of breath), every step counts towards cardiovascular health. Multiple studies have shown a sharp drop in mortality as the amount of daily movement we undertake increases, eventually reaching a plateau at around five hours of light physical activity. All kinds of movement count, not just exercise classes or a run.

In particular, short bursts of higher-intensity movement in our daily lives have "tremendous potential, provided that they are repeated regularly" and conducted with sufficient intensity, says Emmanuel Stamatakis at the University of Sydney, who last year published the first study of the health impacts of so-called vigorous intermittent lifestyle physical activity. Stamatakis and his colleagues found that just three 1-minute bouts of intense movement per day – such as a burst of fast walking to catch a bus – halved the risk of death from cardiovascular disease. In fact, the impact of these short bursts in non-exercisers resulted in similar effects to the vigorous physical activity of exercisers.

Stamatakis suggests thinking about how we can add a bit more vigour to our daily activities. This could be walking up the stairs a little quicker, carrying your shopping rather than using a trolley or putting a little bit more intensity into gardening or housework.

One way to help make these changes could be to get a dog. A 2019 study found that people who own dogs are more likely to be physically active than those who don't. More radically, you could turn the thermostat down, because shivering counts as exercise too. In fact, exercise and exposure to the cold have more in common than you might realise: they both trigger a lipid called 12,13-diHOME to be released into the blood, prompting muscles to burn fat. This could mean that exercising in the cold, such as cold-water swimming, results in more bang for your buck.

If this is too daunting, there could be the option of tapping directly into the benefits of biochemicals released by the body in response to exercise without being active at all. Many drug development projects are looking into this (see "Exercise pills", right), but alas, no such tablets will be available any time soon.

There might be other ways to boost fitness through technology. Our shoes could be capable of helping our exercise performance, for instance. After the Nike Vaporfly trainer was released to great fanfare in 2017, amateur runners began turning to "super shoes" in their droves. Studies have demonstrated that the Vaporfly's midsole foam and carbon fibre plate can indeed reduce the energetic cost of running by between 2.7 and 4.2 per cent compared with typical running shoes.

There is a catch, however. This only seems to apply to fast runners capable of achieving a sub-3-hour-15-minute marathon. Research from earlier this year indicated that, for slower runners who take around an hour longer to complete this distance, the benefits were reduced to 0.9 per cent.

Don't despair: help with running can come in other ways. Recent research shows that a supportive sports bra can improve the performance of female runners by 7 per cent.

For the less athletic among us, electronic muscle stimulation (EMS) devices could be a way of building muscle from the comfort of the couch. These devices, available in various forms since the 1950s, use electrical impulses to directly stimulate your motor neurons, eliciting a muscle contraction. There is considerable evidence to show that EMS can improve muscle strength and thickness, and even reverse atrophy caused by inactivity.

So where does all this leave me in my fitness quest? It seems that there are some surprising low-effort tweaks that all of us can make to improve our strength and stamina, whether we are regular exercisers or completely sedentary. For me, losing 8 kilograms of fat seems like an ambitious goal, but, as psychologists like Crum might tell me, the limitations are only in my mind. ■

YURI ARCURS/ALAMY

The mind is an overlooked factor in our fitness

Exercise pills

Researchers are getting closer to developing a pill that mimics the effects of exercise. Last year, for instance, a study showed that a drug called locamidazole could increase the number of mitochondria in the muscles and bones of mice, one of the typical consequences of exercising. Mice that received locamidazole also had greater bone mineral density, wider muscle fibres and greater endurance on a treadmill. Another promising substance is an amino acid called Lac-Phe, which is released in the blood during endurance and resistance training. A 2022 study found that giving Lac-Phe to mice for 10 days helped reduce their levels of body fat. At present, however, there are no trials of these substances in humans.

David Cox is a freelance writer based in Brighton, UK. He tweets @DrDavidACox

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60-second psychology

A green office

Studies show the unexpected benefits of working outside, from better concentration to reduced anxiety, says **David Robson**

David Robson is an award-winning science writer and the author of *The Expectation Effect: How your mindset can transform your life*

AS THE northern hemisphere enters the summer season, I am spending more of my working day in my tiny London garden. It's not just a way of coping with the rising temperatures – though it is undoubtedly more pleasant to sit in the fresh air than in a stuffy office. According to recent research, time spent outdoors can bring a brain boost.

One benefit comes from plant life. According to "attention restoration theory", plants provide an optimum level of visual stimulation to replenish concentration when we start to lose focus. This idea is grounded in our evolution: our brains are adapted to the environments we would have encountered in prehistory, and we therefore find them more restful and less tiring. In line with this idea, multiple studies have shown that contemplating natural scenes improves performance on cognitive tests requiring focused attention. Indeed, simply looking at images of nature seems to help restore concentration when our attention is waning. People who spend some of their working day in a natural environment report reduced anxiety and greater job satisfaction too.

GARY YEOWELL/GETTY IMAGES

Working outside will also increase our exposure to natural sunlight, which brings its own benefits. Sunlight famously stimulates the production of vitamin D, which appears to influence the production of proteins known as "neurotrophic factors" that are essential for the building of new brain circuits. Sunlight may also stimulate the production of glutamate, a neurotransmitter directly involved in learning and memory. Laboratory mice that had been given a low dose of UV light – equivalent to moderate sunlight exposure – found it easier to differentiate between new and familiar objects.

If the same is true in humans, you might expect that greater exposure to sunlight would result in better overall brain health, including reduced risk of neurodegeneration – and a few recent papers support the idea. Danish scientists found that people who work outdoors are less likely to develop Parkinson's disease, while a study from China reported that moderate exposure to outdoor sunlight – 1 to 2 hours a day – was associated with a lower risk of Alzheimer's.

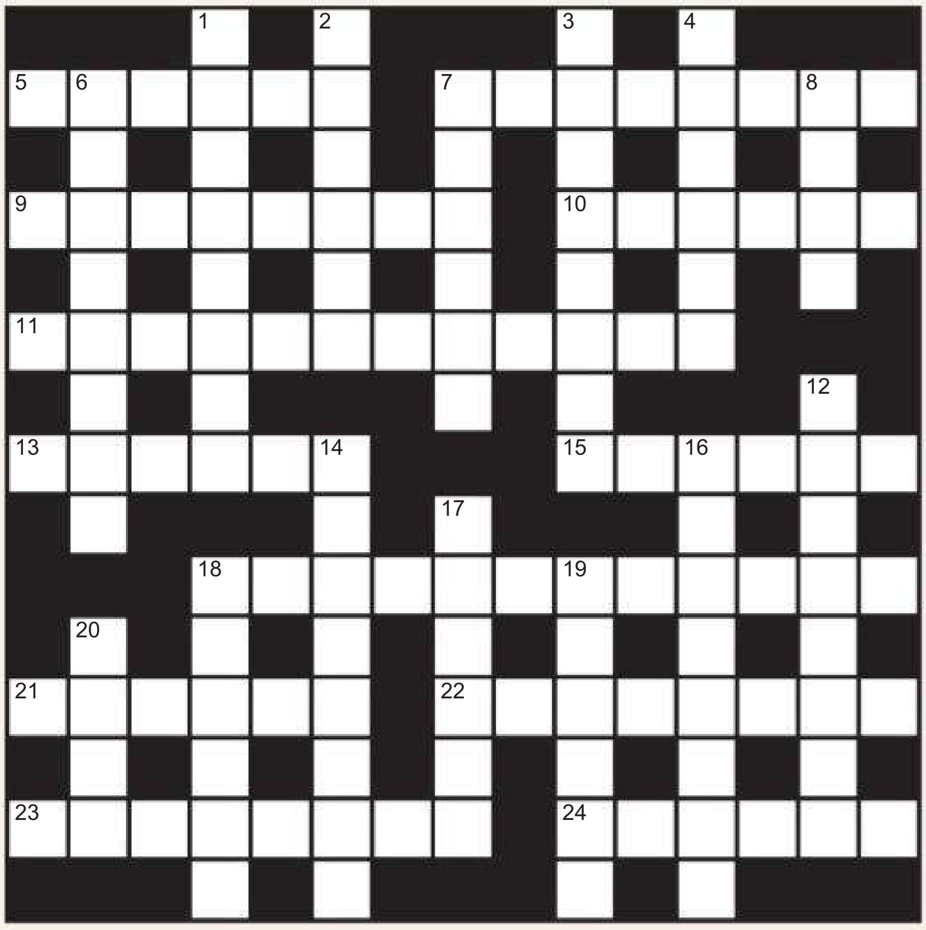
This must, of course, come with caveats. Given the dangers of too much UV exposure, we must all take the necessary precautions to protect our skin. And having lived in a small flat for more than a decade, I am aware that it can be difficult for many city dwellers to find a quiet and clean outdoor space. But if you do have the chance to do so, taking your work outside or going for a mid-morning or mid-afternoon walk in the park may be an easy way to supercharge your thinking and make the most of your mind. ▮

60-second psychology appears monthly

Next week
Stargazing at home

These articles are posted each week at newscientist.com/maker

Quick crossword #136 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

5 Component of arthropod exoskeletons (6)
7 Short-lived insects (8)
9 Stickiness; the action or process of sticking (8)
10 High-mobility multipurpose wheeled vehicle used by the US military (6)
11 Calculi (6,6)
13 Insect's wing covering (6)
15 Headphone formerly supplied with Apple devices (6)
18 What a positron is to an electron (12)
21 Diamorphine (6)
22 Shaped like a die (8)
23 Part of the large intestine (8)
24 Substances that are neither liquid nor gas (6)

DOWN

1 Family of wired networking technologies (8)
2 Thing (6)
3 As luck would have it (2,6)
4 Fire (6)
6 Chris ___, Canadian astronaut (8)
7 1/525600th of a year (6)
8 Female sheep (4)
12 ___ dove, bird in the family Columbidae (8)
14 Ac, Th or Pa, say (8)
16 Precipitation (8)
17 US spacecraft company (6)
18 Black-and-white wading bird (6)
19 Monosaccharide, $C_5H_{10}O_5$ (6)
20 Electronic noise (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #208
set by Bethan Ackerley

1 What name is given to the graph measuring the build-up of carbon dioxide in the atmosphere?

2 Chars, trout and graylings are all members of which family of fish?

3 What is the world's largest inland body of water by surface area?

4 *Treponema pallidum pallidum* causes which sexually transmitted infection?

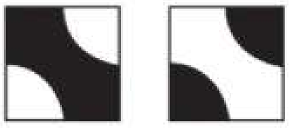
5 Phylloquinone, menaquinones and menadione are the three types of which vitamin?

Answers on page 47

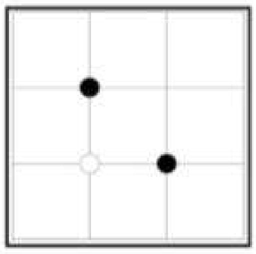
Headscratcher
set by Colin Beveridge

#228 A knight on the tiles

My latest artistic commission is to create a pattern using two kinds of "Truchet" tiles, one with a black diagonal, the other with a white diagonal, like this:



My client, Sir Mo Sayik, is being incredibly fussy. He wants the tiles to be set on the specific 3 x 3 grid shown below.



He also wants the artwork to follow three rules. Firstly, wherever tiles join, the colours must match. Secondly, the black dots shown on the grid must have exactly three black diagonals touching them, and the white dot must have exactly three white diagonals touching it. And thirdly, the finished pattern can't have any "islands" of black or white – all shapes formed must connect to an edge. Tiles can be rotated of course. Can you help?

Solution next week

Big spin

So much in the universe spins. Could the universe itself be spinning?

Pat French
Telford, Shropshire, UK
If there is only one universe, then there is nothing to relate to its movement; there is no backdrop against which its rotation can ever be observed.

Imagine that you are in the ballroom of a cruise ship at night. Nothing is visible through the portholes. You can see the glitter ball rotating in the centre of the ceiling. You can see the dancers moving in various circles with reference to each other and to the walls of the room, but you can't see whether the ship is sailing in circles or a straight line.

However, if the ship is circling so fast that you can experience a centrifugal force pushing you outwards, this might tell you that it is indeed circling.

Unfortunately, even if a centrifugal force is present (and possibly contributing to our ever-expanding universe), we can't measure it – yet.

> **"We would need instruments that could measure tiny changes compared with another observed universe"**

If there is more than one universe, then we must wait until the others are observed and judge the movement of "our" universe relative to those.

Our little galaxy, the Milky Way, takes 200 million years to rotate once. We can measure that rotation.

For the rotation of the entire universe, we would need instruments that could measure incredibly tiny changes compared with another observed universe over immense timescales at a distance representing the dawn of time.

We can't measure that – yet.

EZRA BAILEY/GETTY IMAGES

Are these shadows affecting the weight of the street they are cast over?

This week's new questions

A bit shady **Do shadows weigh anything? And do they affect the weight of objects they are cast over?** ***Ben Walsh**, London, UK*

Cutting edge **When a cut scabs over, why does it then become itchy and we get an urge to scratch it? From an evolutionary viewpoint, this seems to make no sense, as it means the wound is at risk of infection.** ***Guy Cox**, Sydney, Australia*

David Bortin
Whittier, California, US
I think that, in general, "have angular momentum" is a preferred equivalent term to "be spinning".

It is widely (but not unanimously) accepted among scientists and philosophers that the concept that electrons and other particles are actually spinning – and at velocities faster than the speed of light, no less – is a paradoxical one.

But the term "electron spin" was adopted because these particles do, incontrovertibly, exhibit angular momentum, which would be observed as spinning in macroscopic objects.

The principle that angular momentum must be conserved is often illustrated by the statement that the angular momentum of a planet, manifested as rotation or spin, must equal the sum of the angular momenta of all its constituent particles and parts. It would follow, by inference and extrapolation, that yes, our entire physical universe must be spinning as well. Or it must, at least, have angular momentum.

What our universe is spinning in relation to is, much like the spin of an electron, a bit of a philosophical riddle.

John Hastings
Whittlesey, Cambridgeshire, UK
Mach's principle holds that rotation is determined by the overall distribution of matter. For example, Earth is rotating with respect to the background of "fixed" stars. Our Milky Way galaxy is spinning in relation to the background of all the other galaxies.

If the universe is infinite, there is no background against which the universe could rotate.

If our universe is finite, but there are no other universes, Mach's principle (if it is true) would imply that the universe can't be spinning.

If our universe exists in a multiverse, it could be rotating with respect to the background of other universes, but since we can't observe any other universes, how could we discern whether the universe is rotating?

There are two ways we can tell that Earth is rotating (other than by observing the daily movement of the stars from our perspective). One is to observe a Foucault pendulum, which oscillates in a fixed plane while Earth rotates around it. The second is to measure Earth and note that it bulges at the equator due to the centrifugal force produced by the planet's rotation.

So we would need an internal observation or experiment that demonstrates the rotation of our universe. (Does the universe "bulge" at its "equator"?)

Hillary Shaw
Newport, Shropshire, UK
If the universe were spinning, it would have an axis of spin, whether it were spinning in some wider 3D space or as the 3D "surface" of a 4D hypersphere. This would create a centrifugal force that would be weaker towards the spin axis.

In turn, the apparent gravity (that is, gravity minus the centrifugal spin effect) slowing the universe's expansion would be stronger at the spin axis and we could observe differences in the expansion rate (i.e. different redshifts of stars) in different parts of the universe.

But we don't.

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Tom Gauld

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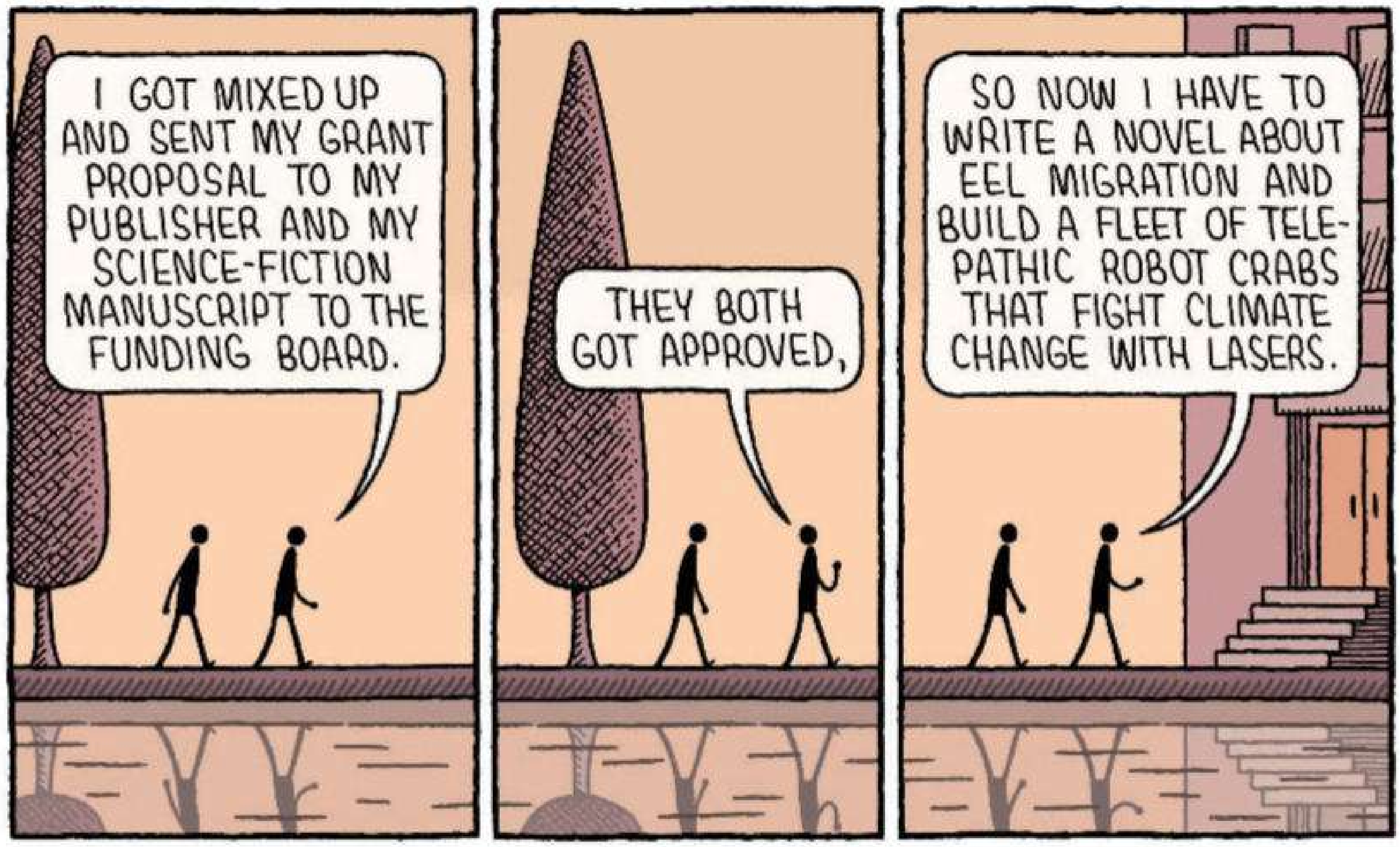

I GOT MIXED UP AND SENT MY GRANT PROPOSAL TO MY PUBLISHER AND MY SCIENCE-FICTION MANUSCRIPT TO THE FUNDING BOARD.
THEY BOTH GOT APPROVED,
SO NOW I HAVE TO WRITE A NOVEL ABOUT EEL MIGRATION AND BUILD A FLEET OF TELEPATHIC ROBOT CRABS THAT FIGHT CLIMATE CHANGE WITH LASERS.

Veni, vidi, vici

Do we actually know how the ancient Romans pronounced Latin words? (continued)

Georgina Skipper
Weymouth, Dorset, UK
The evidence for the hard "c" sound in Latin is strong, but more interesting is the reason for the shift to the soft "c" before "e" and "i" in modern languages.

These vowels are formed further forwards in the mouth and "k" is formed at the back. We may be seeing the same sort of thing happening in speech by people from Liverpool, UK, where "k" is pronounced further forwards, with a hiss, and seems to be on a path to becoming an "s". This applies to soft and to hard "g", which is the voiced version of "k".

However, I can't find any evidence that the ancient Greeks had a "v" sound, so they may have rendered the Latin "v" as their "w" because it was closest to that, not because it is what that actually sounded like.

> "The evidence for the hard 'c' sound in Latin is strong, but more interesting is the shift to the soft 'c' before 'e' and 'i' seen today"

All modern Latinate languages seem to manage without a "w" (French people typically pronounce it "v"), using other combinations with "u" for the "w" sound and pronouncing "v" as "v" or "b". This is complicated by the fact that the Romans used "v" as a vowel as well as a consonant. It is possible that the sound they used was more like in Punjabi, somewhere between the "v" and "w".

Jon Arch
Welwyn Garden City, Hertfordshire, UK
The respondents nicely explained how we know how the Romans pronounced consonants, but said nothing about vowels.

I was taught to pronounce "i" as in "see" (as in modern Italian and Spanish) and "ae" as in "eye", but the English-speaking world has largely swapped round these pronunciations. It has also added a third for "ae", so the "ae" in algae or vertebrae is sometimes pronounced as in "hay". Could previous respondent Eric Kvaalen now offer his insight on Roman vowels, please?

John Healey
Semaphore, South Australia
Further to the pronunciation of Latin words, perhaps those who use plural Latin words ending in "i", such as stimuli, fungi and loci, might take note that these words should be pronounced to rhyme with "bee", not "eye".

And the many names in the Linnaean taxanomical system that end in "ae", such as Leguminosae, Scincidae and Formicinae, should be pronounced to rhyme with "eye", not "bee" or "day". Interested scientists may consult the summary at the end of W. Sidney Allen's *Vox Latina: A guide to the pronunciation of classical Latin*, the book recommended by your correspondent Connaire Kensit. ▮

Answers

Quick quiz #208 *Answers*

1 The Keeling Curve
2 Salmonidae
3 The Caspian Sea
4 Syphilis
5 Vitamin K

Cryptic crossword #112 *Answers*

ACROSS 1 Chrome, **4** Arcsin, **9** Voyager, **10** Bantu, **11** Range, **12** Jasmine, **13** Orion nebula, **18** Tangelo, **20** Tuber, **22** Tiger, **23** Samoyed, **24** Convex, **25** Ingest

DOWN 1 Covert, **2** Rayon, **3** Magneto, **5** Rebus, **6** Sundial, **7** Nausea, **8** Trojan horse, **14** Röntgen, **15** Bitumen, **16** Static, **17** Credit, **19** Eyrie, **21** Boyle

#227 A great deal of magic *Solution*

When Max flips over his own pile of cards at the end of the trick, he mathematically guarantees there will be an equal number of face-up cards in each hand.

Imagine that Max didn't flip over his stack. His volunteer's hand would have X face-up cards and 26 - X face down. Max would have the rest of the face-up cards, again totalling 26 - X, and the remainder of his hand would be face down. The number of these face-down cards would be 26 - (26 - X), or simply X. Once Max flips over his pile, the face-up and face-down cards would switch places, giving him X face-up cards, the same as the volunteer.

The rest of Max's trick, which involved tapping and sliding piles of cards, was just showmanship.

A sick experiment

The phrase “what goes up must come down” isn’t obviously relevant to the insides of a cat.

The countervailing “what goes down must come up” is, when that cat has swallowed something of dubious nutritional worth.

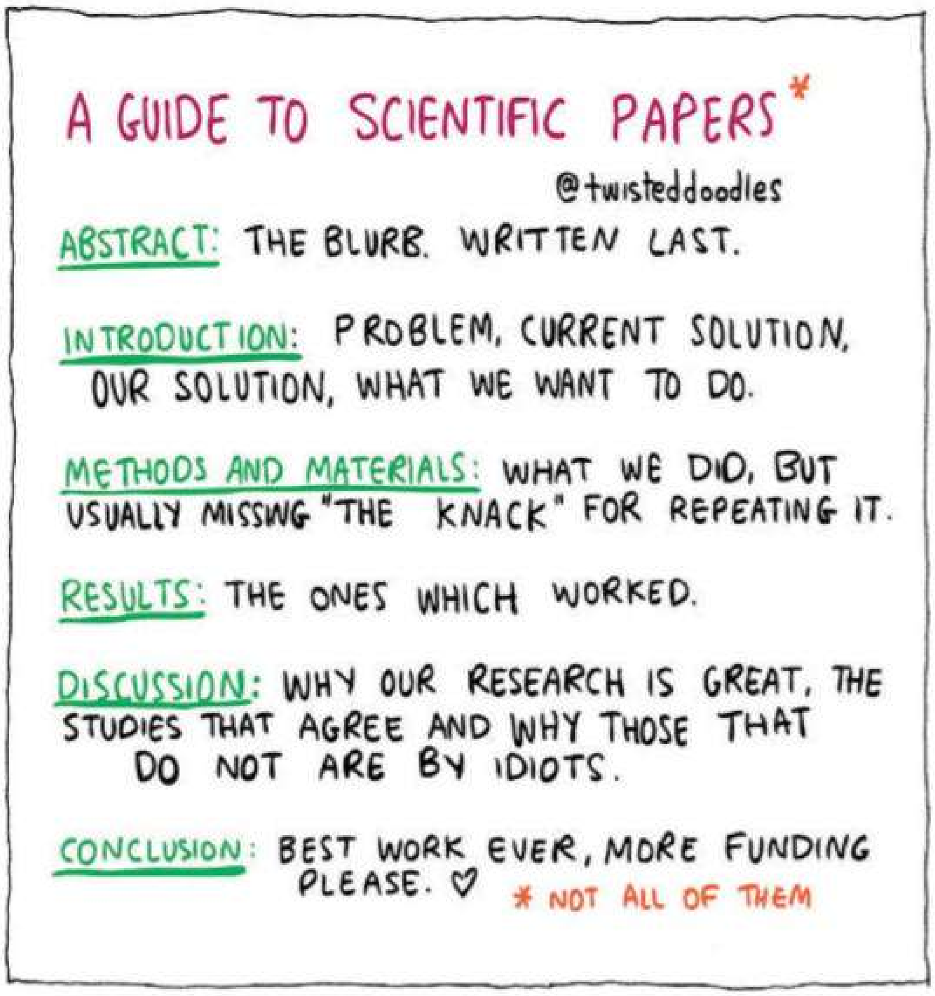
Christiana Fischer, Nolan Chalifoux and Erica Reineke have quantified the “must” aspect of it, as they explain to anyone with the stomach to read their report “Emesis induction is successful for recovery of gastric foreign objects in cats”, published in the *Journal of the American Veterinary Medical Association*.

In their documented experience, objects that have been ingested by cats can be encouraged back up the oesophagus in half of all cases.

The trio of veterinarians, all of whom are based at the University of Pennsylvania, say: “Of the 22 cats that had emesis attempted, 11 (50%) vomited some or all of the foreign object. The time from ingestion to presentation, time from the last meal, presence of food in the vomitus, type of the object, and length, width, and surface area of the object did not influence the likelihood of successful recovery with emesis induction.”

The most common objects the cats ingested, they report, were rubber bands.

Twisteddoodles *for New Scientist*


A GUIDE TO SCIENTIFIC PAPERS*
@twisteddoodles
ABSTRACT: THE BLURB. WRITTEN LAST.
INTRODUCTION: PROBLEM, CURRENT SOLUTION, OUR SOLUTION, WHAT WE WANT TO DO.
METHODS AND MATERIALS: WHAT WE DID, BUT USUALLY MISSING "THE KNACK" FOR REPEATING IT.
RESULTS: THE ONES WHICH WORKED.
DISCUSSION: WHY OUR RESEARCH IS GREAT, THE STUDIES THAT AGREE AND WHY THOSE THAT DO NOT ARE BY IDIOTS.
CONCLUSION: BEST WORK EVER, MORE FUNDING PLEASE. ♡
* NOT ALL OF THEM

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Consideration of items sent in the post will be delayed

Food stuff

Spray-dried animal plasma has yet to hit it big in the food and fine dining industries.

Spray-dried animal plasma is pretty much what it says on the tin. Almost no one yet loudly mentions it as a foodstuff (or partial foodstuff) for humans. Livestock industries have been more welcoming, using spray-dried animal plasma as a food additive for piglets, calves and young chickens.

The substance, sometimes also made from pigs, cows and poultry, is attractive for more than just its possible yumminess. There is cost, in this age of rising food prices. There is efficiency, in the drive to minimise food waste by maximising recycling. And there is, maybe, good health for the elderly. A new study suggests that “Dietary supplementation with spray-dried animal plasma improves vaccine protection in aged mice”.

The pet food industry has taken spray-dried animal plasma to its bosom. Reports indirectly show how the little-bits-of-everything substance could become tempting for chefs and food vendors.

In Spain, Javier Polo and Carmen Rodríguez have written a series of studies about not only its “functional properties”, but also some of the simple pleasures that spray-dried animal plasma can bring to a meal. Yumminess rises high in their paper called “Improving the juiciness of pet food chunks and pouches with plasma”.

Spray-dried animal plasma – “SDP” to those in the know – potentially offers much to many, even to the littlest among us. A 2021 study says that, while “The effects of SDP on shrimp health is not well understood”, “it could potentially be applied in shrimp farming as an alternative to antibiotics”.

Just like us

Inspired by the old saying that “people are the strangest animals”, Feedback wants to compile a sturdy list of animal behaviour metaphors that also tellingly describe some of our fellow humans.

This could be an enlightening project. The colourful strangenesses characteristic of certain people strongly resemble the colourful strangenesses characteristic of certain species of other, non-human animals, after all.

Such a list might also be useful to professionals. People can be frustrating for psychologists and psychiatrists, who struggle to find simple, clear phrases that capture the essence of each person’s mélange of characteristic behaviours.

Eventually, when equipped with a catalogue of apposite metaphors, psychologists and psychiatrists would be able to calculate the percentages of the world’s human population who are metaphorically cat, dog, fox, sparrow, cockroach, earthworm, snake, shark, ear mite or whatever.

Here is an example, in the form of an 18-word description of aardvark behaviour, which was published in the *Encyclopedia of Animal Cognition and Behavior*: “Aardvarks capture their prey using a combination of their long prehensile tongue, their adhesive saliva, and large claws.” Many of us have a human friend or colleague who behaves almost exactly this way.

You can help us gather a simple but broad-ranging catalogue of these metaphors, which we shall call Human Animal Behavioural Intrinsic Traits (HABITs). Send your entries to feedback@newscientist.com, and please remember to provide your sources.

Snot a superpower

Patrick Laughlin contributes to another of Feedback’s catalogue projects. Laughlin boasts a trivial superpower that can be cultivated and that can extend the joys of childhood into later life.

He says: “In primary school, my best friend and I invented the ‘wahmie’. You occlude one nostril with a fingertip, and blast out snot from the other, directing it to either side. One can become quite accurate with practice. I still use the wahmie when walking in the woods to avoid having to carry tissue, especially in allergy season.” ▮

Marc Abrahams

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